11. Assessment of the Shortraker Rockfish Stock in the Gulf of Alaska

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Executive Summary

Gulf of Alaska rockfish have historically been assessed on a biennial stock assessment schedule to coincide with the availability of new trawl survey data (odd years). In 2017, the Alaska Fisheries Science Center (AFSC) participated in a stock assessment prioritization process. It was recommended that the Gulf of Alaska (GOA) shortraker rockfish remain on a biennial stock assessment schedule with a full stock assessment produced in odd years and no stock assessment produced in even years. For this on-cycle year, we incorporate Relative Population Weights (RPWs) from the 1992 - 2019 longline surveys, incorporate new trawl survey biomass, and update auxiliary data sources.

This stock is classified as a Tier 5 stock. We continue to use a random effects (RE) model fit to survey data to estimate exploitable biomass and determine the recommended ABC, but we present a new method of combining the AFSC longline survey RPW index (1992 - 2019) with the AFSC bottom trawl survey biomass index (1984 – 2019) within the random effects model. The RE model was fit to the time series of trawl survey biomass and longline survey RPW indices by region (with associated estimates of uncertainty). These regional biomass estimates from the RE model were then summed to obtain Gulfwide biomass.

Summary of Changes in Assessment Inputs

Changes in the input data: The input data were updated to include bottom trawl survey biomass and length composition estimates for 2019, longline survey Relative Population Numbers (RPNs), RPWs, and length compositions from 2018 and 2019, final 2017 and 2018, and preliminary 2019 (through October 1, 2019) length compositions and total catch from the trawl and longline fisheries.

Changes in the assessment methodology: The methodology used to estimate exploitable biomass to calculate ABC and OFL values for the 2020 fishery has changed. This year, a random effects model, utilizing the bottom trawl survey biomass index from 1984 - 2019 and the AFSC longline survey RPW index from 1992 – 2019, is recommended. This new methodology has been requested for Tier 5 species that are assessed with a random effects model that fits estimates of biomass from the AFSC bottom trawl survey and are also sampled by the longline survey.

Summary of Results

The summarized results of the risk matrix exercise for this stock are in the table below. The overall score of level 1 suggests no need to set the ABC below the maximum permissible. Further details for each category of this risk matrix are provided in the *Harvest Recommendations* section.

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ ecosystem considerations*	*Fishery Performance considerations*	*Overall score (highest of the individual scores)*
Level 1: Normal	**Level 1:** Normal	**Level 1:** Normal	**Level 1:** Normal	**Level 1:** Normal.

For the 2020 fishery, we recommend the maximum allowable ABC of 708 t for shortraker rockfish. This ABC is 18% lower than the 2019 ABC of 863 t. The OFL is 944 t. Reference values for shortraker rockfish are summarized in the following table, with the recommended ABC and OFL values in bold. The stock was not being subjected to overfishing in 2018.

Quantity	As estimated or *specified last* year for: 2019	2020	As estimated or *recommended this* year for: 2020	2021
M (natural mortality rate)	0.03	0.03	0.03	0.03
Tier	5	5	5	5
Biomass (t)	38,361	38,361	31,465	31,465
F_{OFL}	F=M=0.03	F=M=0.03	F=M=0.03	F=M=0.03
$maxF_{ABC}$	0.75M=0.0225	0.75M=0.0225	0.75M=0.0225	0.75M=0.0225
F_{ABC}	0.0225	0.0225	0.0225	0.0225
OFL (t)	1,151	1,151	**944**	944
maxABC (t)	863	863	708	708
ABC (t)	863	863	**708**	708
Status	As determined *last* year for: 2017	2018	As determined *this* year for: 2018	2019
Overfishing	No	n/a	No	n/a

Updated catch data (t) for shortraker rockfish in the Gulf of Alaska as of October 1, 2019 (NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database, http://www.akfin.org) are summarized in the following table.

Year	Western	Central	Eastern	Gulfwide Total	Gulfwide ABC	Gulfwide TAC
2018	38	325	400	763	863	863
2019	27	154	355	536	863	863

Note that there was a slight overage of allowable catch in the Central GOA (20 t) in 2018. The 2018 apportioned ABC for the Central GOA was 305 t (Echave and Hulson 2017).

Area Apportionment

For apportionment of ABC/OFL, the random effects model was fit to area-specific biomass and subsequent proportions of biomass by area were calculated. The following table shows the recommended apportionment, estimated biomass, and ABC value by regulatory area for 2020.

	Regulatory area: Western	Central	Eastern	Total
Area Apportionment	7.4%	40.1%	52.5%	
Estimated Area Biomass (t)	2,328	12,618	16,519	31,465
Area ABC (t)	52	284	372	708
OFL (t)				944

Summaries for Plan Team

All values are in tons.

Species	Year	Biomass[1]	OFL	ABC	TAC	Catch[2]
Shortraker Rockfish	2018	38,361	1,151	863	863	763
	2019	38,361	1,151	863	863	536
	2020	31,465	944	708		
	2021	31,465	944	708		

Stock/		2019				2020		2021	
Assemblage	Area	OFL	ABC	TAC	Catch[2]	OFL	ABC	OFL	ABC
Shortraker rockfish	W		44	44	27		52		52
	C		305	305	154		284		284
	E		515	515	355		372		372
	Total	1,151	863	863	536	944	708	944	708

[1]Total biomass for 2018 and 2019 was calculated with the random effects model utilizing bottom trawl biomass indices. Biomass for 2020 was calculated with the random effects model utilizing the bottom trawl biomass and the longline survey RPW indices.

[2]Current as of October 1, 2019. Source: NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database (http://www.akfin.org).

Responses to SSC and Plan Team Comments on Assessments in General

"Secondly, a few assessments incorporate multiple indices that could also be used for apportionment. The Team recommends an evaluation on how best to tailor the RE model to accommodate multiple indices." (Plan Team, November 2015)

In this year's assessment we present and recommend a random effects model that incorporates both the AFSC bottom trawl survey biomass index and the AFSC longline survey RPW index to estimate exploitable biomass and recommend management quantities.

"The SSC requests that all authors fill out the risk table in 2019…" (SSC, December 2018)

"…risk tables only need to be produced for groundfish assessments that are in 'full' year in the cycle." (SSC, June 2019)

"The SSC recommends the authors complete the risk table and note important concerns or issues associated with completing the table." (SSC, October 2019)

We have grouped these comments as they pertain to the same topic. We provide a risk table as recommended by the SSC. Following the completion of this exercise, the authors do not recommend that the ABC be reduced below maximum permissible ABC.

"Stock assessment authors are encouraged to work with ESR analysts to identify a small subset of indicators prior to analysis, and preferably based on mechanistic hypotheses." (SSC, October 2018)

The Gulf of Alaska has experienced a marine heatwave since September 2018, and the 2019 EcoFOCI spring larval survey indicated below average abundance of rockfish. How these warm temperatures affect shortraker rockfish in their various life history stages is unknown. Authors will continue to examine this.

Responses to SSC and Plan Team Comments Specific to this Assessment

"The Plan Team recommended that authors … explore incorporating the longline survey RPWs into area apportionment calculations." (GOA Plan Team, November 2015)

"The SSC supports the author's and PT's suggestion to explore incorporating the longline survey relative population weight as an additional index for future apportionment." (SSC, December 2015)

"The Team reiterates their recommendation to examine the trawl survey and longline survey (within depth strata) for the purposes of improving the area apportionment and understanding the spatial structure. (GOA Plan Team, November 2016)

"The Team supports development of including longline survey data in the random effects model for apportionment." (GOA Plan Team, November 2017)

"The Team recommended that this approach with new data be presented for consideration in November." (GOA Plan Team, September 2019)

"The SSC endorses bringing this RE model forward as an option in November, in agreement with the PT. However, SSC requests clarification on the 'optimal' method used to weight the surveys at the December meeting." (SSC, October 2019)

We have grouped these comments as they pertain to the same topic. As stated above, in this year's assessment we present and recommend a random effects model that incorporates both the AFSC bottom trawl survey biomass index and the AFSC longline survey RPW index to estimate exploitable biomass and recommend management quantities. Further, the longline survey index is used with the trawl survey biomass index in such a manner that it is directly influential on apportionment. We have also provided justification for the choice of relative weighting between the bottom trawl survey biomass (1) and the longline survey RPWs (0.5) in the Model Results section. Although, we note that it should be recognized that 'optimal' data weighting in stock assessment is a topic that has been extensively researched but has yet to be resolved. Unfortunately, it remains the case that at some level the stock assessment scientist must make a subjective choice as to the relative data weighting.

Introduction

The North Pacific Fishery Management Council (NPFMC) established shortraker rockfish, *Sebastes borealis*, as a separate management category in the Gulf of Alaska (GOA) in 2005. Previously, shortraker rockfish had been grouped from 1991 to 2004 with rougheye rockfish in the "shortraker/rougheye" management category because the two species are similar in appearance, share the same habitat on the upper continental slope, and often co-occur in hauls. Both species were assigned a single overall ABC (acceptable biological catch) and TAC (total allowable catch), and fishermen were free to harvest either species within this TAC. However, evidence from the NMFS Alaska Groundfish Observer Program indicated that shortraker rockfish were being harvested disproportionately within the shortraker/rougheye group, which raised the possibility that shortraker could become overexploited (Clausen 2004). Because of this concern, the NPFMC decided to establish separate management categories for shortraker and rougheye rockfish starting with the 2005 fishing season.

From 2005 to 2010, the assessment for shortraker rockfish was combined with that for another management group of rockfish in the GOA, "other slope rockfish." Although shortraker rockfish and "other slope rockfish" had separate harvest specifications, their assessments were presented in a single SAFE chapter because each group was assessed using a similar methodology based on the NPFMC's "tier 5" definition of overfishing. However, in 2010 both the GOA Groundfish Plan Team and the NPFMC Scientific and Statistical Committee (SSC) recommended that future assessments for shortraker rockfish and "other slope rockfish" be presented in separate SAFE chapters.

General Distribution

Shortraker rockfish, *Sebastes borealis*, range from Hokkaido Island, Japan, north into the Sea of Okhotsk and the Bering Sea, and through the Aleutian Islands and Gulf of Alaska south to southern California. Its center of abundance appears to be Alaska waters. In the GOA, adults of this species inhabit a narrow band along the upper continental slope at depths of 300-500 m; outside of this depth interval, abundance decreases considerably (Ito 1999). Much of this habitat is steep and difficult to trawl in the GOA, and observations from a manned submersible also indicated that shortraker rockfish seemed to prefer steep slopes with frequent boulders (Krieger and Ito 1999). Adult shortraker rockfish may also be associated with *Primnoa* spp. corals that are used for shelter (Krieger and Wing 2002). Research focusing on non-trawlable habitats found rockfish species often associate with biogenic structure (Du Preez and Tunnicliffe 2011, Laman *et al*. 2015), and that shortraker rockfish are often found in both trawlable and untrawlable habitats (Rooper and Martin 2012, Rooper *et al*. 2012). Several of these studies are notable as results indicate adult shortraker biomass may be underestimated by traditional bottom trawl surveys because of issues with extrapolating survey catch estimates to untrawlable habitat (Jones *et al*. 2012, Rooper *et al*. 2012).

Life History Information

Life history information on shortraker rockfish is extremely sparse. The fish are presumed to be viviparous, as are other *Sebastes*, with internal fertilization and development of embryos, and with the embryos receiving at least some maternal nourishment. There have been no fecundity studies on shortraker rockfish. One study on reproductive biology of the fish in the northeastern Pacific (most samples were from the GOA) indicated they had a protracted reproductive period, and that parturition (larval release) may take place from February through August (McDermott 1994). Another study indicated the peak month of parturition in Southeast Alaska was April (Westrheim 1975). Most recently, the reproductive development stage of shortraker rockfish was examined from samples collected opportunistically in the GOA throughout the year in 2008-2014 (Conrath 2017). Similar to McDermott's (1994) findings, shortraker rockfish were found to be seasonal synchronous spawners, with the onset of development occurring in the late summer months and parturition taking place from March through May. There is no information on when males inseminate females or if migrations occur for spawning/breeding.

Genetic techniques have been used to identify a small number of post-larval shortraker rockfish from samples collected in epipelagic waters far offshore in the GOA, which is the only documentation of habitat for this life stage (Kondzela *et al*. 2007). No data exist on when juvenile fish become demersal in the GOA; in fact, few specimens of juvenile shortraker rockfish <35 cm fork length have ever been caught in this region, so information on this life stage is virtually absent. Off Kamchatka, juvenile shortraker are reported to become demersal starting at a length of about 10 cm (Orlov 2001). Orlov (2001) has also suggested that shortraker rockfish may undergo extensive migrations in the north Pacific. In his theory, which is mostly based on size compositions of shortraker rockfish in various regions, larvae/post-larvae of this species are transported by currents from the GOA to nursery areas in the Aleutian Islands, where they grow and subsequently migrate back to the GOA as young adults. More research is needed to substantiate this scenario. As mentioned previously, adults are particularly concentrated in a narrow band along the 300-500 m depth interval of the continental slope. Within the slope habitat, shortraker rockfish tend to have a relatively even distribution when compared with the highly aggregated and patchy distribution of many other rockfish such as Pacific ocean perch (Clausen and Fujioka 2007). Shortraker rockfish attain the largest size of all *Sebastes*, with a maximum reported total length of 120 cm (Mecklenburg *et al*. 2002).

Evidence of Stock Structure

The stock structure of the GOA shortraker rockfish was examined and presented to the GOA Groundfish Plan Team in November 2016 (Echave *et al.* 2016). There are few data available to differentiate stocks across regions, and with such little information on growth and reproduction, what is available is insufficient for evaluating comparisons within the spatial extent of the species. The limited genetic information available have indicated evidence of stock structure in the GOA (Gharrett *et al.* 2003; Matala *et al*. 2004), but additional research is needed to better define this structure. Although not conclusive, the genetic studies do not support Orlov's theory of extensive migrations for shortraker rockfish. Please see Appendix 11.A of the 2016 GOA shortraker rockfish assessment for a more thorough evaluation of the potential stock structure for GOA shortraker rockfish (Echave *et al.* 2016).

Fishery

Fishery History

Throughout the 1991-2004 period during which shortraker/rougheye rockfish existed as a management category in the GOA, directed fishing was not allowed, and the fish could only be retained as "incidentally-caught" species. This incidental catch status has continued for shortraker rockfish since it became a separate category in 2005. In the years since 2005, shortraker rockfish have been taken mostly in fisheries targeting rockfish, sablefish, and Pacific halibut, with lesser amounts taken in the walleye pollock and other groundfish fisheries (Table 11-1).

Shortraker rockfish can be caught with both trawls and longlines. The percent caught in each gear type is listed in the following table for the years 1993-2019[1]. Note that for 1993-2004, information on catch by gear is only available for the shortraker/rougheye category and not for shortraker alone. Since 2004, shortraker catch has generally been caught in equal amounts on both trawl (pelagic and nonpelagic combined but majority caught on nonpelagic trawl) and longline gear, with the exception of 2010, 2011, 2016, and 2018.

[1]1993-2019: National Marine Fisheries Service, Alaska Region, Catch Accounting System, accessed via the Alaska Fishery Information Network (AKFIN). Catches updated through October 1, 2019.

Shortraker/Rougheye Rockfish – Percentage Caught by Gear Type												
Gear	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Trawl	67.7	54.4	73.3	71.2	72.1	58.8	61.2	63.5	49.4	60	68.5	49.5
Longline	32.3	45.6	26.7	28.8	27.9	41.2	38.8	36.5	50.6	40	31.5	50.5

Shortraker Rockfish – Percentage Caught by Gear Type												
Gear	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Trawl	54.8	49.2	54	53.2	56	39.3	63.2	48.7	48.6	48.6	48.7	62.3
Longline	45.2	50.8	46	46.8	44	60.7	36.8	51.3	51.4	51.4	51.3	37.7

Shortraker Rockfish – Percentage Caught by Gear Type			
Gear	2017	2018	2019
Trawl	51.5	42.7	47.5
Longline	48.5	57.3	52.5

Nearly all of the longline catch of shortraker rockfish appears to have come as “true” incidental catch in the sablefish or halibut longline fisheries. Historically, some of the shortraker catch in rockfish trawl fisheries was taken by actual targeting that some fishermen called “topping off” (Ackley and Heifetz 2001). “Topping off” worked in this way: fishery managers assign all vessels in a directed fishery a maximum retainable amount (MRA) for certain species that may be encountered as incidental catch. If a vessel manages to not catch its MRA during the course of a directed fishing trip, or the MRA is set overly high (as data presented in Ackley and Heifetz [2001] suggest), before returning to port the vessel may be able to make some target hauls on the incidental species and still not exceed its MRA. Such instances of “topping off” for shortraker rockfish appeared to have taken place in the Pacific ocean perch trawl fishery. Fisherman may have been motivated to “top off” because shortraker rockfish are the most valuable trawl-caught *Sebastes* rockfish in terms of landed price. However, this practice is generally thought to not occur in present times and all shortraker catch is truly incidental.

In 2007, the Central Gulf of Alaska Rockfish Pilot Program was initiated to enhance resource conservation and improve economic efficiency for harvesters and processors who participate in the Central GOA rockfish fishery. In 2012 this pilot program was permanently put into place as the Central Gulf of Alaska Rockfish Program. This is a rationalization program that established cooperatives among trawl vessels that receive exclusive harvest privileges for rockfish management groups (for details, see North Pacific Fishery Management Council, 2008). The primary rockfish management groups for the program are Pacific ocean perch, northern rockfish, and pelagic shelf rockfish, but there is a small allocation for shortraker rockfish. Catches of shortraker rockfish taken by trawlers in the Central GOA decreased in 2007 (North Pacific Fishery Management Council 2008), and the catches have remained relatively low in the Central GOA in following years, with the exception of 2016 and 2018. Other effects of the pilot program include: 1) mandatory at-sea and plant observer coverage for vessels participating in the program, which has greatly improved catch data for rockfish in the Central GOA; and 2) extending the fishery season when most trawl-caught shortraker rockfish are taken. Previously, most shortrakers were taken as incidental catch during the directed “derby-style” trawl fisheries for Pacific ocean perch, northern rockfish, and pelagic shelf rockfish, which mostly occurred during July. In the Rockfish Program, trawling can occur anytime between May 1 and November 15, and catches are now spread over this period.

Management Measures and History

The NPFMC established shortraker rockfish as a separate management category in the GOA in 2005. Previously, shortraker rockfish had been grouped from 1991 to 2004 with rougheye rockfish in the "shortraker/rougheye" management category because the two species are similar in appearance, share the same habitat on the upper continental slope, and often co-occur in hauls. Both species were assigned a single overall ABC (acceptable biological catch) and TAC (total allowable catch), and fishermen were free to harvest either species within this TAC. However, evidence from the NMFS Alaska Groundfish Observer Program indicated that shortraker rockfish were being harvested disproportionately within the shortraker/rougheye group, which raised the possibility that shortraker could become overexploited (Clausen 2004). Because of this concern, the NPFMC decided to establish separate management categories for shortraker and rougheye rockfish starting with the 2005 fishing season.

From 2005 to 2010, the assessment for shortraker rockfish was combined with that for another management group of rockfish in the GOA, "other slope rockfish." Although shortraker rockfish and "other slope rockfish" were distinct management entities, their assessments were presented in a single SAFE chapter because each group was assessed using a similar methodology based on the NPFMC's "tier 5" definition of overfishing. However, in 2010 both the GOA Groundfish Plan Team and the NPFMC SSC recommended that future assessments for shortraker rockfish and "other slope rockfish" be presented in separate SAFE chapters.

In practice, the NPFMC apportions the ABCs and TACs for shortraker rockfish in the GOA into three geographic management areas: the Western, Central, and Eastern Gulf of Alaska. This apportionment is to disperse the catch across the Gulf and prevent possible depletion in one area.

A timeline of management measures that have affected shortraker rockfish, along with the corresponding Gulfwide annual catch and ABC/TAC/OFL levels are listed Table 11-2.

Catch History

Official fishery catch statistics for shortraker rockfish in the GOA are only available for 2005-2019, when the species catch was first reported separately for management purposes (Table 11-3). However, catch statistics are available for shortraker and rougheye rockfish combined for the years 1991-2004, when both species were classified together into one management group, and these are also listed in Table 11-3. Previous to 1991, shortraker rockfish was classified into larger management groups that included Pacific ocean perch and other species of *Sebastes*, and it is generally not possible to separate out the shortraker catches.

Although official catch statistics for shortraker rockfish started only in 2005, unofficial estimates of the Gulfwide catch of shortraker rockfish for the years 1993-2003 were computed in Clausen (2004). These unofficial estimates are shown in Table 11- 4. The estimates are based on a combination of data from the observer program and the NMFS Alaska regional office, and take into account differences in catch by area and by gear type. The estimates indicate that annual shortraker catch was generally around 1,000-1,500 t during these years. Annual TACs for the shortraker/rougheye group were the major determining factor of these catch amounts. As shown in Table 11-3, the total Gulfwide catch of shortraker/rougheye for a given year was generally very similar to the corresponding TAC. The 2005-2019 shortraker rockfish official catches have been consistently lower than any of the unofficial estimates in previous years. These low catches in the last nineteen years correspond to the years when shortraker rockfish has been in its own management category separate from rougheye rockfish. This suggests that the breakup of the shortraker/rougheye group may have caused the subsequent reduction in catch of shortraker rockfish, but the exact reasons for the lower catches are unclear.

Catch of shortraker rockfish varies greatly by area, gear type, and year (Figure 11-1). Before the prohibition of trawling east of 140 degrees W longitude in the EGOA in 1999, shortraker rockfish were predominately caught on trawl gear (average 67% of catch). Note that for 1993-2004, information on catch by gear is only available for the shortraker/rougheye category and not for shortraker alone. Since 1999, trawl and longline gear have generally each comprised about half the annual Gulfwide catch, however, the dominant gear type for shortraker catch varies significantly by region. Since 2010, the majority of shortraker catch in the CGOA has been on nonpelagic trawl gear, with longline gear generally catching less than half the trawl amount (Figure 11-2). While shortraker rockfish are generally caught on trawl gear in the rockfish fishery, the recent spike in the CGOA in 2016 was the result of the anomalously large amount of shortraker catch in the pollock fishery (Table 11-1). Why there was such a higher than average amount of shortraker catch (174 t in 2016 versus historical average of <6 t) in the pollock fishery in 2016 is unknown, but this is likely the major contributor to the ABC overage. 61% of the shortraker catch in 2016 on nonpelagic trawl gear occurred during July, and the majority of this catch was near the entrance of Amatuli Gully, an area that generally catches a larger amount of shortraker rockfish on the trawl survey (Echave *et al.* 2016) but in recent years has not reported any large hauls of shortraker rockfish. Additionally, the depth distribution for shortraker rockfish from survey data (300 – 500 m) and the average fishing depth (172 m) of the observed GOA pollock fleet don't appear to have changed. In contrast, shortraker rockfish are caught predominantly on longline gear in the EGOA (Figure 11-2). However, since hitting a historical low in 2014 (42 mt), trawl catch in the EGOA (West Yakutat) has increased substantially, and as of 1 October 2019, is almost equal to longline catch of shortraker rockfish in 2019 (Figure 11-2). In the WGOA, shortrakers are predominately caught on longline gear (Figure 11-2).

Exploitation rates of shortraker rockfish also vary considerably by area, gear type, and from year to year, but have generally been low and relatively stable (Figure 11-3). The exception is the nonpelagic trawl fisheries in the Western and Central GOA, which have been extremely variable over time. For example, an annual rate of change from 0.006 to 0.032 (exploitation rates in the CGOA nonpelagic trawl fishery in 2012 and 2013, respectively), is a common event. Additionally, the WGOA hook and line fishery has shown large annual variability in recent years. Exploitation rates in 2019 decreased in all areas and for all gear types, with exception in the WGOA, which saw a large increase in the hook and line fishery (increase from 0.013 to 0.06), and a moderate increase in the nonpelagic trawl fishery (0.001 to 0.003). In general, shortraker rockfish are most exploited in the WGOA and least in the EGOA.

Survey research catches of shortraker rockfish are a very small component of overall removals and recreational and other catches are assumed negligible. Non-commercial (research and sport) catches of shortraker rockfish are reported and discussed in Appendix 11A.

Bycatch

The only analysis of bycatch in shortraker/rougheye rockfish fisheries of the Gulf of Alaska is that of Ackley and Heifetz (2001), in which they examined data for 1994-1996 only. In the hauls they identified as targeting shortraker/rougheye (most of which were presumably "topping off" hauls as described previously), the major bycatch was arrowtooth flounder, sablefish, and shortspine thornyhead, in descending order by weight.

Discards

Discard rates of shortraker rockfish are higher than those for the three species of *Sebastes* in the GOA that have directed fisheries (Pacific ocean perch, northern rockfish, and dusky rockfish), but are less than the "Other rockfish" management category in this region (see chapters in this SAFE report for Pacific ocean perch, northern rockfish, dusky rockfish, and other rockfish). Discard rates for shortraker rockfish have been increasing in recent years, reaching a Gulfwide historical high of 55.8% in 2018 (Table 11-5). In addition, discard rates have become more disproportionate between gear types. For example, the 2019 Gulfwide discard rate is, on average, ~9% in the trawl rockfish fisheries and ~74% in the hook and line sablefish fishery (Table 11-5).

Why shortraker discard rates are increasing is not completely understood. The high 2016 Gulfwide value is likely due in part to the previously mentioned higher than average catch of shortraker rockfish in the pollock trawl fishery, which reported historical high catch (174 t) and a discard rate of 100%. This high discard rate is likely because vessels did not want to exceed the low aggregated rockfish MRA of 5% in the pollock fishery. Historically, the discard rate of shortraker rockfish in the pollock fishery has been 0 – 1%, corresponding with low catch of <6 t. Shortraker rockfish went on prohibited species catch (PSC) status on 19 September 2016 in both the WGOA and CGOA and therefore the vast majority of shortrakers were discarded after 19 September, however, only 17% of the observed shortraker catch occurred after 19 September 2016, and most of the shortraker catch in the pollock fishery in 2016 were during the fall pollock fishery and before the stock went to PSC status (J. Bonney, Alaska Groundfish Data Bank, pers. comm.).

The more recent high Gulfwide values in 2018 and 2019 are from an increase in hook and line discards in the EGOA. While the overall increase in discard rates in the hook and line sablefish fishery is not completely understood, the MRA rate (7%) for hook and line boats still lends to overage concerns for vessels. Possible explanations for the reportedly high discard rate in the sablefish fishery include the following: 1) regulatory discards due to low sablefish catch onboard, 2) potentially biased discard values among the fishery catch data, and 3) an increase in shortraker catch due to change in fishery behavior. Logbook and observer data have shown seasonal variation in depths fished during the IFQ season: boats that target sablefish fish at shallower depths in the spring (March – May), and move deeper as the season progresses. When vessels fish the upper slope edge during the early season (~190 – 250 fm), they are more likely to catch a greater number of rockfish and are therefore forced to discard early in the trip as there are often not enough sablefish on board for retention of shortrakers (D. Falvey, ALFA, pers. comm.). The same explanation could apply during times of heavy whale depredation. When a first set is heavily depredated by whales, the vessel will move and likely catch enough sablefish on subsequent sets to accommodate the amount of bycatch of the first set. However, the rockfish caught on the first set would have been discarded under current regulation (D. Falvey, L. Behnken, ALFA, pers. comm.). Additionally, the influx of the large 2016 sablefish year class (Hanselman *et al.* 2018) has flooded the fishery with small, low valued sablefish. It has been noted by fishermen that there has been increase in shortraker catch and subsequent discards as the catch rates have increased while modifying fishing behavior to avoid the small sablefish. While observer data is incredibly useful, it is important to keep in mind that the estimate of the amount of catch that is discarded at sea for each species encountered in the haul is based on the observer's best professional judgment, and is challenging because it can occur at many places in a fishing and processing operation (Cahalan et al. 2010). These estimates are then applied to the unobserved fleet, and if data is limited or based on a small number of hauls with large catch, these numbers have the potential of being extrapolated to inaccurate values. Future work looking at electronic monitoring (EM) data may help answer potential extrapolation bias questions. In short, industry representatives state that the market for shortraker rockfish is good and that there are no processor restrictions. The practice of discarding bycatch species exist because of enforcement concerns.

Data

Fishery Data

Catch

Detailed catch information for shortraker/rougheye and shortraker rockfish is listed in Table 11-3.

Size and Age Composition

While the number of lengths sampled by observers for shortraker rockfish in the Gulf of Alaska commercial fishery are few, we are able to use available data to compare length frequencies by gear type

(Figure 11- 4). Unimodal length frequency distributions and average length caught are similar between both gear types in the commercial fishery: the average length of shortraker caught in the longline fishery is 57.7 cm, and 58.7 cm in the nonpelagic trawl fishery. Few age samples for this species have been collected from the fishery, and none have been aged.

Survey Data

Longline Surveys in the Gulf of Alaska

Two longline surveys of the continental slope of the Gulf of Alaska provide data on the relative abundance of shortraker rockfish in this region: the earlier Japan-U.S. cooperative longline survey, and the ongoing Alaska Fisheries Science Center (AFSC) domestic longline survey. These surveys compute relative population numbers (RPNs) and relative population weights (RPWs) for fish on the continental slope as indices of stock abundance. The surveys are primarily directed at sablefish, but also catch considerable numbers of shortraker rockfish. Results for both surveys concerning rockfish, however, should be viewed with some caution, as the RPNs and RPWs do not take into account possible effects of competition for hooks with other species caught on the longline, especially sablefish. An analysis of the survey data indicated there was a negative correlation between catch rates of sablefish and shortraker rockfish in the Gulf of Alaska, and that there was likely competition for hooks between species in the surveys (Rodgveller *et al.* 2008). The study concluded that further research and experiments are needed to better quantify the effects of hook competition and to compute adjustment factors for the surveys' catch rates. Recently, another study compared catch rates of shortraker and rougheye rockfish on survey longline gear with observed densities of these fish around the longline from a manned submersible (Rodgveller *et al.* 2011). Results for shortraker and rougheye combined showed a catchability coefficient (q) of 0.91. There was a tendency for longline catch rates of the two species to be related to the observed densities, but this relationship was not significant. Again, this study concluded that additional research is needed on the longline catching process for shortraker rockfish to better determine the suitability of using longline survey results for assessment of this species.

The cooperative longline survey was conducted annually during 1979-94, but RPNs for rockfish are only available for the years 1979-87 (Sasaki and Teshima 1988). These data are highly variable and difficult to interpret, but suggest that abundance of shortraker rockfish remained stable in the Gulf of Alaska (Clausen and Heifetz 1989). The data also indicate that shortraker rockfish are most abundant in the eastern Gulf of Alaska.

The AFSC domestic longline survey has been conducted annually since 1988, and RPNs and RPWs have been computed for each year (Table 11-6). For shortraker rockfish, Gulfwide RPNs have ranged from a low of ~12,650 in 1992 to a high of ~32,000 in 2000 (Table 11-6). Definite trends in these data over the years are difficult to discern, and the Gulfwide values of RPN and RPW sometimes fluctuate considerably between adjacent years. For example, the RPW in 2009 was 36,691 t, dropped to 23,688 t in 2010, and increased to 34,215 t in 2011. Some of the fluctuations may be related to changes in the abundance of sablefish, as discussed in the previous paragraph regarding competition for hooks among species. The 2019 longline survey RPW value for shortraker rockfish is up 14% from 2018 (Figure 11-5). This is just slightly below the historical average.

Similar to the cooperative longline survey, the AFSC domestic longline survey results show that abundance of shortraker rockfish is highest in the eastern Gulf of Alaska; the Yakutat area consistently has the greatest RPN and RPW values for shortraker rockfish.

Longline Survey Size Compositions

Length frequency data from the 2019 AFSC domestic longline survey shows a unimodal distribution with an average length of 62.8 cm; this value is up from the long term average (60.4 cm; Figure 11-6). Shortraker rockfish lengths recorded on the 2019 bottom trawl survey have a similar unimodal distribution and mean length. The 2019 longline survey mean length is slightly larger than the average length (57.7 cm) caught in the 2019 observed hook and line fishery.

AFSC Trawl Survey Biomass Estimates

Bottom trawl surveys were conducted on a triennial basis in the Gulf of Alaska in 1984 through 1999, and these surveys became biennial starting in 2001 (Table 11-7). The surveys provide much information on shortraker rockfish, including estimates of absolute abundance (biomass) and population length compositions. The trawl surveys have covered all areas of the GOA out to a depth of 500 m (in some surveys to 1,000 m), but the 2001 survey did not sample the eastern GOA. To compensate for this lack of sampling in 2001, substitute values of biomass were computed for this area in 2001 by averaging the eastern GOA biomass estimates in the three previous trawl surveys (for details, see Heifetz *et al.* 2001). Also, the 1984 and 1987 survey results should be treated with some caution. A different, non-standard survey design was used in the eastern Gulf of Alaska in 1984; furthermore, much of the survey effort in the western and central Gulf of Alaska in 1984 and 1987 was by Japanese vessels that used a very different net design than what has been the standard used by U.S. vessels throughout the surveys. To deal with this latter problem, fishing power comparisons of rockfish catches have been done for the various vessels used in the surveys (for a discussion see Heifetz et al. 1994). Results of these comparisons have been incorporated into the biomass estimates discussed here, and the estimates are believed to be the best available. Even so, the reader should be aware that an element of uncertainty exists as to the standardization of the 1984 and 1987 surveys.

Gulfwide biomass estimates for shortraker rockfish have sometimes shown rather large fluctuations between surveys; for example, biomass was 62,317 t in 2015, decreased by 49% to 31,534 t in 2017, and has now increased 42% to 44,773 t in 2019 (Table 11-7). However, the confidence intervals have usually overlapped (Table 11-7 and Figure 11-7). There had been a general upward trend in the biomass estimates since 1990, with the exception of 2017 being the first substantial decrease (approximately 49% from 2015) since 1990. In 2019, all GOA areas show an increase in biomass with the exception of an 83% decrease in Shumagin and a slight 2% decrease in Kodiak (Table 11-7).

Spatial distribution of catches of shortraker rockfish in the last three GOA trawl surveys indicate the fish are rather evenly spread in a band along the continental slope (Figure 11-8). The 2019 survey continues the trend seen in 2017 with fewer large catches but an increase in near shore catch of shortraker rockfish (Figure 11-8). In the Yakutat area in 2013, there was a very large catch of over 1,900 kg in a single haul, and again in 2015 there was a single haul of over 1,200 kg in the Yakutat area and over 1,110 kg in the Southeast area. In contrast, the largest haul in 2019 was just under 525 kg in the Southeast Area, and the second highest was 361 kg in the Yakutat Area. This absence of large catches in 2019 are responsible at least in part for the narrow confidence bounds of the 2019 biomass estimate and the lowered coefficient of variation (CV) of 28.1%. Compared with many other species of *Sebastes*, the biomass estimates for shortraker rockfish have historically shown relatively moderate confidence intervals and low CVs (compare CVs for shortraker in Table 11-7 vs. those for sharpchin, redstripe, harelequin, and silvergray rockfish in the “Other Rockfish” chapter of this SAFE report). The low CVs are an indication of the generally even distribution of shortraker rockfish that was noted in the introduction of this chapter.

Despite the relative precision of the biomass estimates historically, assessment authors have been uncertain whether the trawl surveys are accurately assessing abundance of shortraker rockfish. Nearly all the catch of these fish is found on the upper continental slope at depths of 300-500 m. Much of this area in the GOA is not trawlable by the survey’s gear because of the area’s steep and rocky bottom, except for gully entrances where the bottom is more gradual. Consequently, biomass estimates for shortraker rockfish are mostly based on the relatively few hauls in gully entrances, and they may not be showing a true picture of abundance or abundance trends. One possible problem in the trawl survey results can be seen when longline survey RPWs for shortraker rockfish are compared with corresponding statistical area biomass estimates from trawl surveys. Historically, the longline survey has consistently indicated that shortraker rockfish are most abundant in the Yakutat area, and catches in this area often comprise >50% of the Gulfwide RPW for this species. In contrast, the trawl survey results by area have been much more variable, and the Yakutat area, with few exceptions, has never stood out as a particular area of high abundance. This example highlights the trawl survey's inability to accurately assess abundance of shortraker rockfish, and the longline survey may still be providing a better relative index of abundance by area, as the longline gear can be fished nearly anywhere in the steep 300-500 m slope environment inhabited by shortraker rockfish.

Trawl Survey Size Compositions

Size compositions for shortraker rockfish from the 1990-2007 and 2011-2019 trawl surveys were all unimodal, with almost no fish < 35 cm in length (Figure 11-9). However, results from the 2009 trawl survey were different because there was a modest catch of small fish that ranged in size between 10 and 35 cm long. The reason these small fish occurred in 2009, and not in the other surveys, is unknown. The 2001 results may be biased by the fact that they do not include fish from the eastern GOA because this area was not sampled that year. Shortraker rockfish are generally larger in the eastern Gulf of Alaska (e.g., Martin and Clausen 1995; Martin 1997; von Szalay et al. 2008 and 2010) and the 2001 survey seems to be missing many fish >70 cm in length compared to the other surveys. Based on trawl survey samples the mean length of the shortraker rockfish population in the Gulf of Alaska progressively declined from 61.2 cm in 1990 to 53.9 cm in 2003, followed by increases in 2005, 2007, 2011, 2013, 2015, and 2017 with a mean for the latter year of 62.8 cm. The 2019 mean of 61.6 cm is a slight decrease. The relatively low mean length in 2009 of 54.7 cm is largely attributable to the fish < 35 cm that were caught that year. Mean length of shortraker rockfish caught on the trawl survey (all years combined; 59.3 cm) is similar to the mean length observed in the trawl fishery (nonpelagic trawl all years combined; 58.7 cm).

Trawl Survey Age Compositions

Shortraker rockfish have long been considered among the most difficult rockfish species to age. The usual method for determining rockfish ages, i.e., counting annular growth zones on otoliths, did not appear to work because the growth pattern of shortraker otoliths is so unclear. However, Hutchinson (2004) developed a new aging method for this species based on using thin sections of otoliths and on applying an innovative set of aging criteria to determine which growth bands correspond to annuli. A comparison between his results and those of a previous radiometric study of shortraker rockfish age (Kastelle *et al.* 2000) indicated general agreement and provided a limited degree of validation. This new aging methodology was used to determine the age compositions of shortraker rockfish in the 1996, 2003, and 2005 GOA trawl surveys (Figure 11-10). Ages ranged from 5 to 146 years, and the results indicate the shortraker rockfish population in the GOA is quite old (mean age varied between 32 and 44 years, depending on the survey). To provide direct validation of the new aging method, in 2008 a validation study was conducted based on carbon 14 levels in shortraker rockfish otoliths from nuclear bomb testing in the 1960s. Results were unsuccessful, however, because carbon 14 could not be found in sufficient quantities in the otoliths[2]. Thus, alternative validation techniques will be necessary to verify the aging methodology. One possibility is to conduct an updated and more detailed radiometric study than the previously mentioned Kastelle *et al.* (2000) study, which was done before Hutchison (2004) and was somewhat problematic because it was based on using length of the fish as a proxy for age.

Because of the lack of direct validation for the aging method, and the consequent uncertainty about the ages, production aging for shortraker rockfish has now been put on hold. Due to this uncertainty, use of an age-structured model to assess Gulf of Alaska shortraker rockfish is not recommended at present.

[2] C. Hutchinson, National Marine Fisheries Service, Alaska Fisheries Science Center, REFM Division, 7600 Sand Point Way NE, Seattle WA 98115. Pers. commun. Jan. 2009.

Although we hope to move to an age-structured assessment at some time in the future, better validation of the shortraker rockfish aging methodology is needed before we do so.

Analytic Approach

Modeling Approach

Due to the lack of biological information for shortraker rockfish (especially an absence of validated age data), recent assessments used a biomass-based approach based on trawl survey data to calculate ABCs. We continue to use this approach through the use of a random effects model (RE). The process errors (step changes) from one year to the next are the random effects to be integrated over and the process error variance is the free parameter. The observations can be irregularly spaced; therefore this model can be applied to datasets with missing data. Large observation errors increase errors predicted by the model, which can provide a way to weight predicted estimates of biomass. Estimates were made using the 1984-2019 GOA trawl survey biomass time series, the 1992–2019 AFSC longline survey RPW time series, and associated estimates of uncertainty. The RE model was fit separately by region, and then summed to obtain Gulfwide biomass estimates.

Shortraker rockfish in the GOA are managed under Tier 5, where OFL = M * exploitable biomass, where M represents natural mortality, and F_{ABC} is estimated by 0.75 * M. The acceptable biological catch (ABC) is obtained by multiplying F_{ABC} by the estimated biomass, ABC ≤ 0.75 * M * biomass. M is assumed equal to 0.03 and is discussed further in the following section.

Modeling Selection

In total, three changes were made to the input data and model configuration in this year's assessment compared to the 2017 assessment. We present these changes in a step-wise manner, building upon each previous model change to arrive at the recommended model for this year's assessment. The following table provides the model case name and description of the changes made to the model.

Model case	Description
15.1	2015 model with data updated through 2019
19.1	15.1 with AFSC longline survey RPWs from 1992-2019 included as an additional population index
19.2	19.1 with relative catchability coefficients between the AFSC bottom trawl survey biomass and longline survey RPWs estimated by region
19.2a	19.2 with the AFSC longline survey RPW index weighted at 0.5 compared to the bottom trawl survey biomass

A brief description of each model case that builds upon 15.1 is provided below.

19.1 – Including the longline survey RPW index
In model 19.1, the AFSC longline survey RPW index is added to the random effects model by estimating a relative catchability coefficient parameter that scales the random effects biomass estimates to the longline survey RPWs. The longline survey RPW index is available with associated uncertainty at the regional scale. The estimate of the longline survey RPW index by region is then given by:

$$\widehat{RPW}_{r,y} = \hat{q}e^{\hat{\varepsilon}_{r,y}}$$

where $\widehat{RPW}_{r,y}$ is the estimated regional (r) RPW in year-y, $\hat{q}$ is the estimated relative catchability coefficient, and $\hat{\varepsilon}_{r,y}$ are the random effects parameter estimates for region-r in year-y. An additional observation error component is then added to the objective function, which is the negative log-likelihood of the model fit to the longline survey RPWs, given by:

$$-lnL_O^L = \lambda_L \sum_Y \frac{1}{2}\left[ln\left(2\pi\sigma_{RPW,r,y}^2\right) + \frac{1}{\sigma_{RPW,r,y}^2}\left(ln\left(\widehat{RPW}_{r,y}\right) - ln\left(RPW_{r,y}\right)\right)^2\right]$$

where $\sigma_{RPW,r,y}^2$ is the regional variance of the longline survey RPW index in year y, $RPW_{r,y}$ is the observed longline survey RPW index by region and year, and λ_L is the weighting coefficient for the longline survey RPW index. Thus, the model has three likelihood components: 1) the process error component (which represents the amount of variation across time of the random effect parameters), 2) the bottom trawl survey biomass index observation error component, and 3) the longline survey RPW index observation error component. It is through the addition of the observation error component of the longline survey index to the total likelihood that the biomass estimates from the random effects model are sensitive to both the bottom trawl biomass and longline RPW indices.

19.2 – Estimating regional relative catchability coefficients
In model 19.2, we estimated regional relative catchability coefficients between the bottom trawl survey biomass and the longline survey biomass with:

$$\widehat{RPW}_{r,y} = \hat{q}_r e^{\hat{\varepsilon}_{r,y}}$$

Noting that the only difference between this equation and the one given in model case 19.1 is the added subscript r, to denote region, to the estimated relative catchability coefficient parameter $\hat{q}$.

19.2a – Weighting the longline survey RPW index
In model 19.2a, we weight the longline survey RPW index by 0.5 (λ_L in the above equation) in order to give additional weight to the bottom trawl survey biomass.

Parameter Estimates

Mortality, Maximum Age, Female Age- and Size-at-50% Maturity:

Estimates of mortality, maximum age, and female age- and size-at-50% maturity for shortraker rockfish are listed as follows:

Mortality rate	Mortality rate method	Maximum age	Age at Maturity	Size at Maturity	Area	References
-	-	120	-	-	BC	1
0.027-0.042	GSI	-	21.4	44.9	WC,GOA,AI,EBS	2,3
-	-	157	-	-	GOA	4
-	-	146	-	-	GOA	5
-	-	-	-	49.9	GOA	6

Area indicates location of study: British Columbia (BC), West Coast of U.S. (WC), Gulf of Alaska (GOA), Aleutians (AI), and eastern Bering Sea (EBS).
GSI: gonad somatic index (Gunderson and Dygert (1988).
References: 1) Chilton and Beamish 1982; 2) McDermott 1994: 3) Hutchinson 2004; 4) Munk 2001; 5) this report; 6) Conrath 2017.

The two values for maximum age of shortraker rockfish in the GOA (146 and 157), if true, would make this species one of the longest-lived of all fishes. McDermott (1994) determined that size-at-50% maturity for female shortraker rockfish was 44.9 cm based on samples collected in several regions of the northeast Pacific, including the Gulf of Alaska, while Conrath's (2017) more recent study based on specimens collected solely from the GOA was slightly larger, at 49.9 cm. Hutchinson's (2004) experimental aging study of shortraker rockfish computed von Bertalanffy growth parameters for females, and he used these parameters to convert McDermott's size-of-maturity to an age-of-50% maturity of 21.4 years. Because it was based on experimental aging, however, and was also determined indirectly, the estimate needs to be confirmed by additional study.

When the shortraker/rougheye category was created in 1991, there was no estimate at that time of *M* or *Z* for shortraker rockfish. Therefore, the SSC suggested the following computation for a proxy estimate of *M*: use the ratio of maximum age of rougheye to shortraker (140/120) from British Columbia and then multiply this value by the mid-point of the range of *Z* for rougheye rockfish in British Columbia (mid-point = 0.025) to yield an *M* of 0.03 for shortraker rockfish. In a later study, *M* for shortraker rockfish was estimated to range between 0.027 and 0.042 (McDermott 1994), so the original estimate of 0.03 for *M* seems reasonable.

Length- and Weight-at-Age:

Length-weight coefficients and von Bertalanffy parameters for shortraker rockfish are listed below. Length-weight coefficients are from the formula $W = aL^b$ where W = weight in kg and L = length in cm (based on data from the 1996 GOA trawl survey in Martin 1997):

Sex	a	b	# sampled
combined	9.85×10^{-6}	3.13	620
males	1.26×10^{-5}	3.07	302
females	1.02×10^{-5}	3.12	318

Von Bertalanffy parameters for shortraker rockfish (GOA = Gulf of Alaska; AI = Aleutian Islands: EBS = Eastern Bering Sea):

Area	Sex	t_0	k	L_{inf} (cm)
GOA/AI/EBS	female	-3.62	0.030	84.60

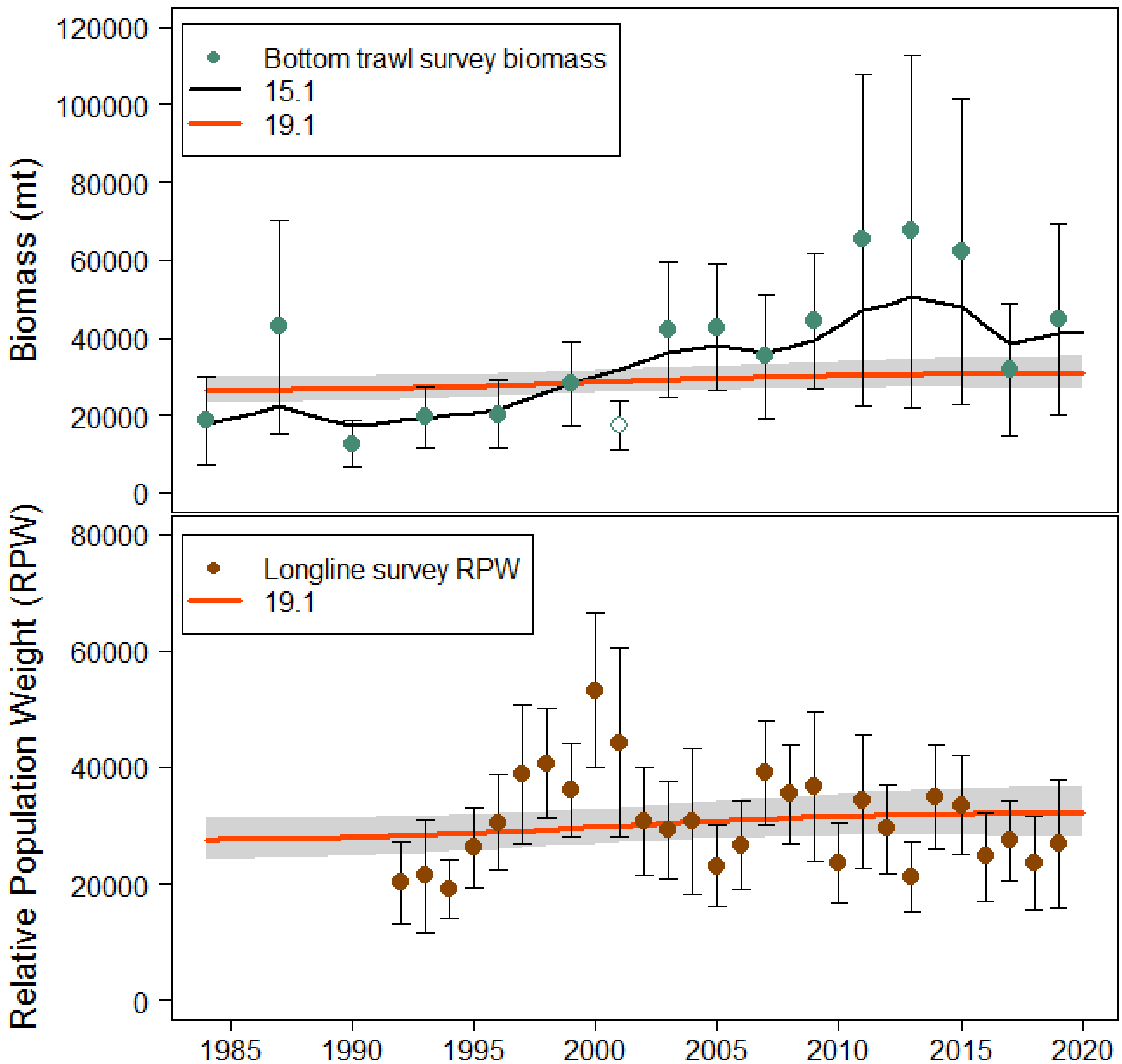
The von Bertalanffy parameters are based on the previously discussed Hutchinson (2004) study which has been only partially validated, so they should be used with caution. Although the analysis combined samples from the GOA, Aleutian Islands, and eastern Bering Sea, most were from the GOA.

Results

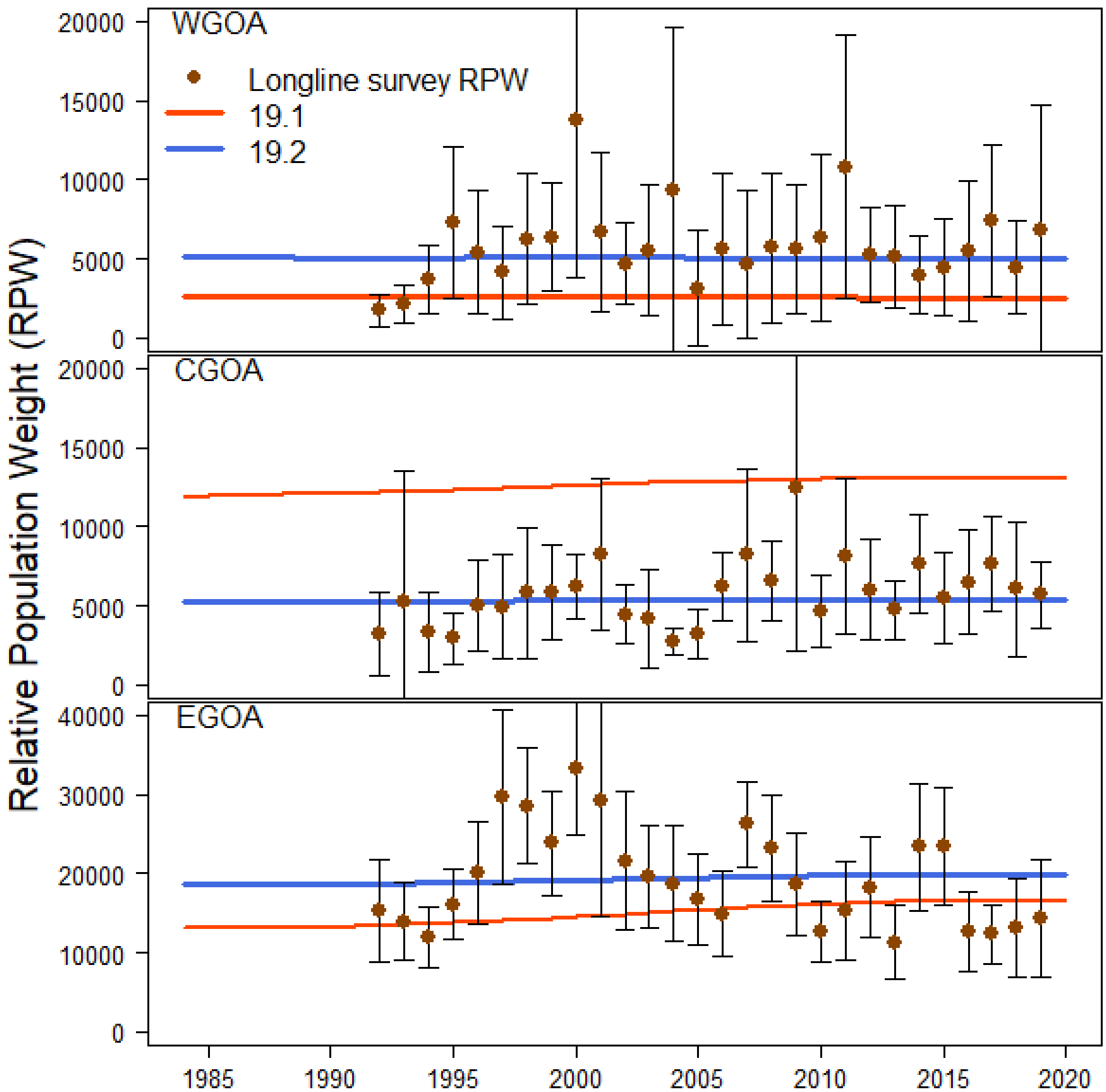
Model Evaluation

In this year's assessment we recommend three changes to the random effects model used to estimate the biomass of shortraker rockfish: (1) including the longline survey RPW index as an additional index to the bottom trawl survey, (2) estimating regional relative catchability coefficients, and (3) weighting the longline survey RPW index by 0.5.

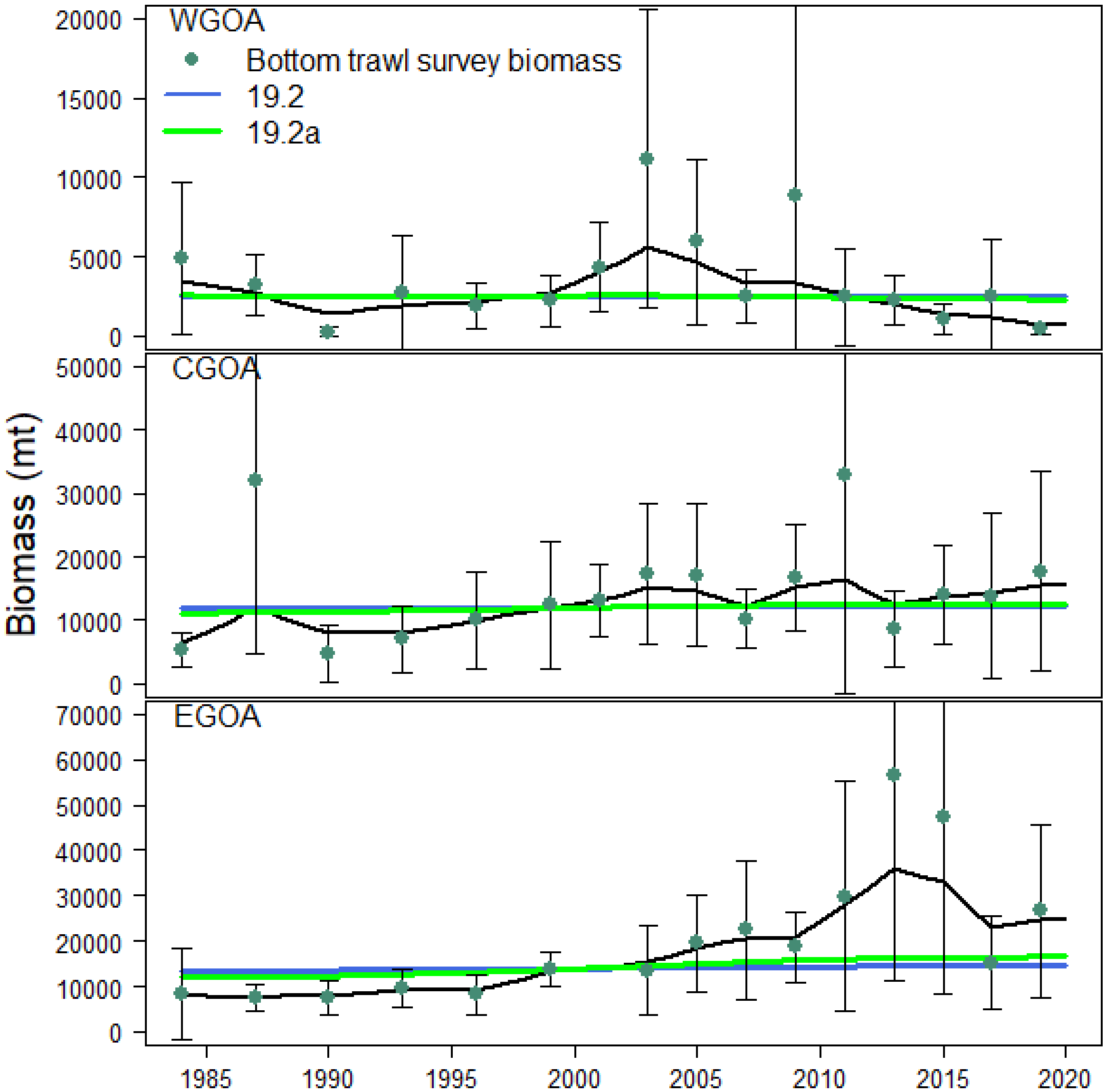
The following figure compares the random effects model fit to the GOA-wide bottom trawl survey biomass index (top panel) and longline survey RPW index (bottom panel) from models 15.1 and 19.1.



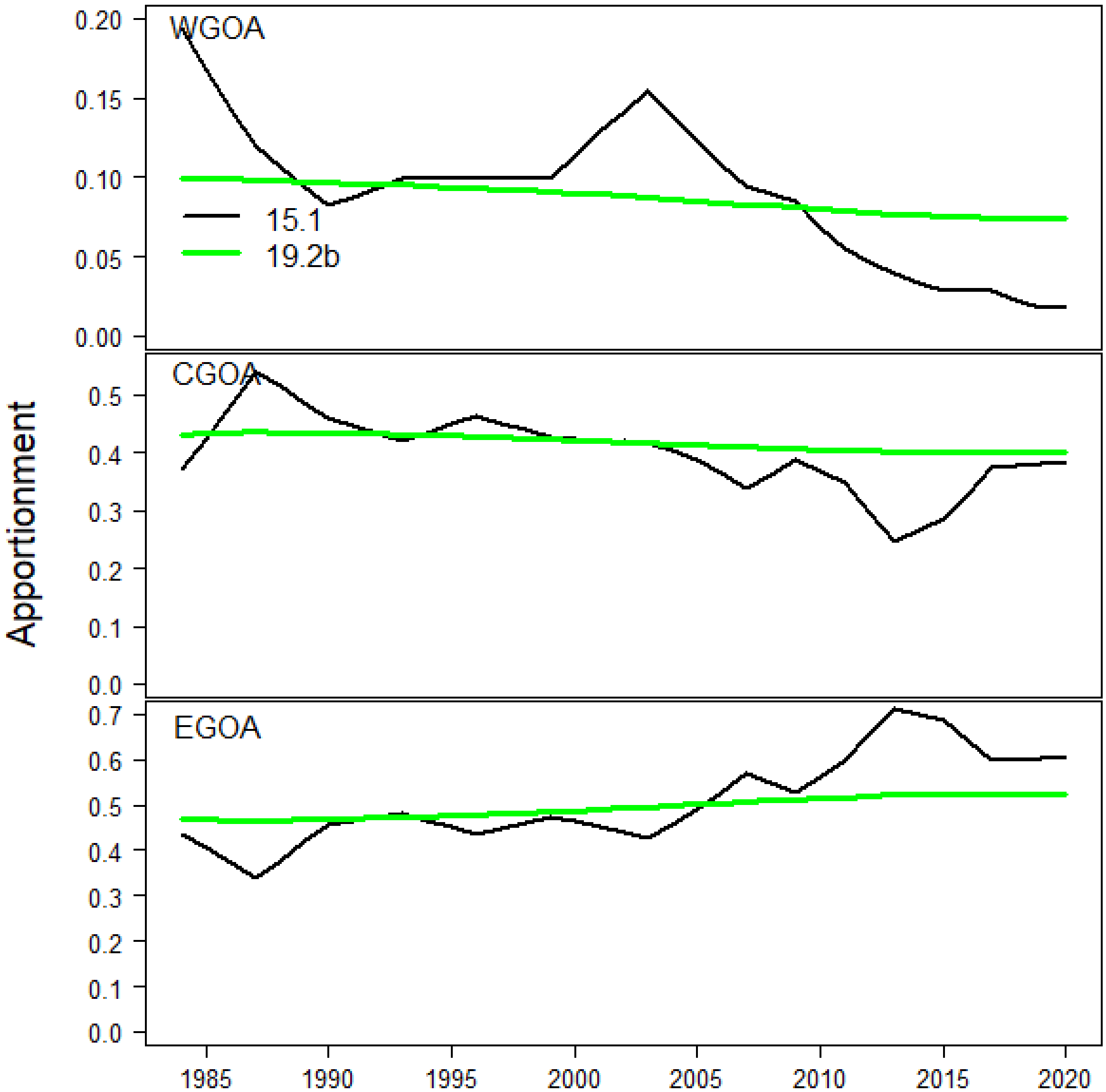
When the longline survey RPW index is introduced into the shortraker rockfish random effects model in 19.1, the fit to the bottom trawl survey index is worse than from model 15.1, although, the stability in estimated biomass across time increases. This is to be expected, as the random effects model will be responsive to the longline survey RPW index, which for shortraker rockfish has smaller relative uncertainty than the bottom trawl survey biomass. The following figure shows the regional fit to the longline survey RPW index from models 19.1 and 19.2.



The fit to regional RPW indices in model 19.1 is poor, in particular for the WGOA and CGOA. Upon estimating regional relative catchability coefficients in model 19.2 the fit to regional RPW indices is improved. We hypothesize that there may be regional differences in availability of shortraker rockfish to trawl and longline gear due to habitat or distribution which is reflected by model 19.1 and resolved with regional relative catchability coefficients in model 19.2. The following figure presents the fit to the regional bottom trawl biomass indices from models 19.2 and 19.2a.



In general, the fit to the regional bottom trawl biomass indices from model 19.2 is reasonable, however, the regional estimates of biomass from model 19.2 result in small changes over time. After weighting the longline survey RPW index by 0.5 in model 19.2a the random effects model is slightly more responsive to the bottom trawl survey biomass index and the estimates of biomass increasingly change over time compared to 19.2, although, these differences are small. As would be expected from the results of the fit to regional indices, the regional apportionment from model 19.2a was more stable across time than the apportionment estimated by model 15.1 (figure below).



The method presented in model 19.1 is a simple and straight-forward approach for including additional population indices in the random effects model used to assess Tier 5 species at AFSC. The general result shown here was an increase in the stability of biomass estimates across time, reduced tendency for the random effects model to over-fit bottom trawl survey biomass values in some years, and more consistent regional apportionment across time. Further, this model exposed potential differences between availability of shortraker rockfish to the bottom trawl survey and the longline survey across regions, which was resolved in model 19.2 by estimating regional relative catchability coefficients. In order to avoid regional biomass estimates that do not change over time (resulting from model 19.2), we recommend that the relative weight of the longline survey be reduced to 0.5 in order to allow regional biomass to change, as in model 19.2a. For these reasons, we recommend that model 19.2a be used for the assessment of shortraker rockfish.

Harvest Recommendations

In previous assessments, shortraker rockfish were always classified as "tier 5" in the NPFMC definitions for ABC and Overfishing Level (OFL) based on Amendment 56 to the Gulf of Alaska FMP. The population dynamics information available for tier 5 species consists of reliable estimates of biomass and natural mortality M, and the definitions state that for these species, the fishing rate that determines ABC (i.e., F_{ABC}) is $\leq 0.75M$. Because age and maturity data are available for shortraker rockfish (Hutchinson 2004), theoretically this species could be moved into tier 4, where $F_{ABC} \leq F_{40\%}$. However, because of the uncertainty of the present aging method and the lack of age validation, we recommend keeping shortraker rockfish in tier 5 for the present. Thus, the recommended F_{ABC} for shortraker rockfish is 0.0225 (i.e., 0.75 x M, where M = 0.03).

The random effects model was used to determine current exploitable biomass that is used to calculate the ABC and OFL values for the 2020 fishery. This method utilizes trawl survey biomass estimates from 1984 - 2019 and AFSC longline survey RPW indices from 1992 - 2019. The random effects methodology has been recommended for all tier 5 stocks managed by the NPFMC. Applying the F_{ABC} to the estimate of current exploitable biomass (using the random effects methodology) of 31,465 t (+/- CI of 26,805 and 36,936) for shortraker rockfish results in a Gulfwide ABC of 708 t and OFL of 944 t for the 2020 fishery (Figure 11-11). This ABC is 18% lower than the 2019 ABC of 863 t.

Should the ABC be reduced below the maximum permissible ABC?

The SSC in its December 2018 minutes recommended that all assessment authors use the risk table when determining whether to recommend an ABC lower than the maximum permissible. The SSC also requested the addition of a fourth column on fishery performance, which has been included in the table below.

	Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 1: Normal	Typical to moderately increased uncertainty/minor unresolved issues in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns	No apparent fishery/resource-use performance and/or behavior concerns
Level 2: Substantially increased concerns	Substantially increased assessment uncertainty/ unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing an adverse signals relevant to the stock but the pattern is not consistent across all indicators.	Some indicators showing adverse signals but the pattern is not consistent across all indicators
Level 3: Major Concern	Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock)	Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types

Level 4: Extreme concern	Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented; More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock; Potential for cascading effects on other ecosystem components	Extreme anomalies in multiple performance indicators that are highly likely to impact the stock

The table is applied by evaluating the severity of four types of considerations that could be used to support a scientific recommendation to reduce the ABC from the maximum permissible. These considerations are stock assessment considerations, population dynamics considerations, environmental/ecosystem considerations, and fishery performance. Examples of the types of concerns that might be relevant include the following:

1. Assessment considerations—
   a. Data-inputs: biased ages, skipped surveys, lack of fishery-independent trend data
   b. Model fits: poor fits to fishery or survey data, inability to simultaneously fit multiple data inputs
   c. Model performance: poor model convergence, multiple minima in the likelihood surface, parameters hitting bounds
   d. Estimation uncertainty: poorly-estimated but influential year classes
   e. Retrospective bias in biomass estimates.
2. Population dynamics considerations—decreasing biomass trend, poor recent recruitment, inability of the stock to rebuild, abrupt increase or decrease in stock abundance.
3. Environmental/ecosystem considerations—adverse trends in environmental/ecosystem indicators, ecosystem model results, decreases in ecosystem productivity, decreases in prey abundance or availability, increases or increases in predator abundance or productivity.
4. Fishery performance—fishery CPUE is showing a contrasting pattern from the stock biomass trend, unusual spatial pattern of fishing, changes in the percent of TAC taken, changes in the duration of fishery openings.

Assessment considerations:

The GOA shortraker stock is a Tier 5 species, meaning only reliable biomass estimates are available to calculate ABCs. The GOA shortraker assessment is one of few Tier 5 assessments in Alaska that is fit to multiple abundance indices (trawl survey biomass estimates and longline survey RPWs). While these two surveys have often shown opposing trends, which is not unexpected due to the differing habitats sampled, the inclusion of these two data sources has allowed for increased stability of biomass estimates and more consistent regional apportionments across time. Historically, the biomass estimates for shortraker rockfish have shown relatively moderate confidence intervals and low CVs. We rated the assessment-related concern as level 1, normal. While biomass estimates have historically shown large changes from year to year (typical of several rockfish assessments), the CVs have generally remained low.

Population dynamics considerations:

In general, very little is known regarding the life history of shortraker rockfish, and current techniques do not produce reliable age estimates for the species. We are unable to estimate recruitment, and very few specimens of shortraker rockfish <35 cm have ever been caught in the GOA. Any data collected during larval cruises lump all rockfish species together. Even with large annual variability, biomass has been trending upward. Overall we rated the population-dynamic concern as level 1, normal, due to the fact that little to no information exists on the population dynamics of this species but that biomass has been trending upward and has shown normal variability for this species.

Environmental/Ecosystem considerations:

Shortraker rockfish are benthic continental slope (300-500m) dwellers as adults (Krieger and Ito 1999), with post-larval rockfish documented in epipelagic waters in offshore waters of the Gulf of Alaska (GOA) (Kondzela *et al.* 2007). Limited information on temperature, zooplankton, and condition of other marine species indicates less favorable foraging and growing conditions for shortraker rockfish during 2019. Sea temperatures were at a record high for the entire GOA during the 2019 summer (Thoman and Walsh 2019). In waters above the continental shelf around Kodiak Island, temperatures were warmer through the water column during spring (6.8°C surface, 6.1°C bottom) and summer (13.3°C surface, 7.3°C bottom to 200m) (Rogers *et al.* 2019) and across the shelf during May (Danielson and Hopcroft 2019). The AFSC bottom trawl survey temperature profiles were similar to 2015 profiles with warmer anomalies (7.0°C) consistently observed across the entire survey area and penetrating to 200 m depths (Laman 2019a). Nearshore mean summer surface temperatures were the second highest on record in northern southeast Alaska, 1997-2019 (Fergusson 2019). Summer and fall temperatures during 2019 indicate heat wave conditions similar to 2015-2016 in the GOA (Barbeaux 2019). It is reasonable to expect that the current heat wave may impact age-0 rockfish in pelagic waters during a time when they are growing to a size that promotes over-winter survival, however it is unknown what this impact will be.

The primary prey items of shortraker rockfish are shrimp, squid, and fish in the GOA (Yang and Nelson 2000). Warm conditions tend to be associated with zooplankton (prey for shrimp, squid, and larval fish) that are dominated by smaller and less lipid rich species in the GOA (Kimmel *et al.* 2019). The biomass of copepods and euphausiids were slightly below the long-term mean along the Seward Line (Danielson and Hopcroft 2019) and around Kodiak Island (Kimmel *et al.* 2019). From 2018 to 2019 in Icy Strait, northern southeast Alaska, the lipid content of all zooplankton taxa examined decreased and were below average, except for euphausiids, indicating a decrease in the nutritional quality of the prey field utilized by larval and juvenile fish (Fergusson and Rogers 2019). Body condition of young-of-the-year pollock in the western GOA in 2019 was lower than the average observed during marine heat wave years of 2005 and 2015-16 (Rogers *et al.* 2019). The body condition of 8 species of adult groundfish species captured near the sea floor in the 2019 AFSC bottom trawl surveys were below average except for adult Pacific cod (Laman 2019b). Little is known about the impacts of predators, such as fish and marine mammals, on shortraker rockfish. The 2019 foraging conditions were below average for larval fish in the GOA. Given that the indicators were warm, but euphausiid abundance spotty and at or slightly average in the GOA and with limited information on rockfish, we scored this category as level 1, normal concern.

Fishery performance:

There is no directed fishing of shortraker rockfish, and they can only be retained as “incidentally-caught.” Catch of shortraker rockfish varies greatly by area, gear type, and year, but catch has always remained below the TAC, and has generally remained stable. Due to their high value, discard rates of shortrakers have generally been low, however, discard rates in the longline fisheries have been increasing in recent years for unknown reasons, but likely due to enforcement concerns. Overall, we rated the fishery performance concern as level 1, normal, due to the low stable catch of this non directed fishery species that historically has always remained below the TAC.

The overall score of level 1 suggests no need to set the ABC below the maximum permissible.

Area Allocation of Harvests

Since 1991, the Gulfwide ABC for shortraker/rougheye rockfish or shortraker rockfish alone has been allocated amongst the Western, Central, and Eastern GOA regulatory areas based on the geographic distribution of the species' exploitable biomass in the trawl surveys. For apportionment of ABC/OFL, the random effects model was fit to area-specific bottom trawl survey biomass (Figure 11-12) and area-specific longline survey RPWs (Figure 11-13) and subsequent proportions of biomass by area were calculated. For the 2020 fishery, the percent distribution of exploitable biomass for shortraker rockfish biomass in the GOA is: Western area, 7.4%; Central area, 40.1%, and Eastern area, 52.5%. Applying these percentages to the recommended Gulfwide ABC of 708 t yields the following apportionments for the GOA in 2020: Western area, 52 t; Central area, 284 t; and Eastern area, 372 t. The recommended WGOA ABC of 52 t is an increase of 18% from the 2019 value of 44 t, the CGOA ABC decreased by 7%, and the EGOA ABC decreased by 28% from the 2019 value of 515 t.

Overfishing Level for Shortraker Rockfish

Based on Amendment 56 in the Gulf of Alaska FMP, overfishing for a tier 5 species such as shortraker rockfish is defined to occur at a harvest rate of F=M. Therefore, applying the estimate of M for shortraker rockfish (0.03) to the estimate of current exploitable biomass (31,465 t) yields an overfishing catch limit of 944 t for 2020. This stock is not being subjected to overfishing.

Summary

A summary of tier, current exploitable biomass, values of F, and recommended ABC (Gulfwide yield and allocated by area) and OFL using the random effects model for shortraker rockfish are listed below for 2020 (biomass and yield are in t):

	Exploit.	ABC		Overfishing	
Tier	biomass	F	Yield	F	Yield
5	31,465	$F = 0.75M = 0.0225$	708	$F = M = 0.030$	944
		Harvest Allocation			
		WGOA	52		
		CGOA	284		
		EGOA	372		

The ABC and OFL values are calculated using the random effects (RE) model. The RE model was fit separately by area, and then summed to obtain Gulfwide biomass. WGOA = Western Gulf of Alaska, CGOA = Central Gulf of Alaska, and EGOA = Eastern Gulf of Alaska.

Ecosystem Considerations

In general, a determination of ecosystem considerations for shortraker rockfish is hampered by the lack of biological and habitat information. A summary of the ecosystem considerations presented in this section is listed in Table 11-8.

Ecosystem Effects on the Stock

Prey availability/abundance trends:

Similar to other rockfish species, stock condition of shortraker rockfish is probably influenced by periodic abundant year classes. Availability of suitable zooplankton prey items in sufficient quantity for larval or post-larval rockfish may be an important determining factor of year-class strength. Unfortunately, there is no information on the food habits of larval or post-larval rockfish to help determine possible relationships between prey availability and year-class strength. Moreover, visual identification to the species level for field-collected larval or post-larval rockfish is generally not reliable, although genetic techniques allow identification for larvae/post-larvae of many rockfish, including shortraker (Gharrett *et. al* 2001; Kondzela *et al.* 2007). Very few juvenile shortraker rockfish have ever been caught in Alaska, and therefore there is no information on their food items. Adult shortraker rockfish are apparently opportunistic feeders that in Alaska prey on shrimp, deepwater fish such as myctophids, and squid (Yang and Nelson 2000; Yang 2003; Yang *et al.* 2006). Little if anything is known about abundance trends of these rockfish prey items.

Limited information on temperature, zooplankton, and condition of other marine species indicates less favorable foraging and growing conditions for shortraker rockfish during 2019. Sea temperatures were at a record high for the entire GOA during the 2019 summer (Thoman and Walsh 2019). Warm conditions tend to be associated with zooplankton (prey for shrimp, squid, and larval fish) that are dominated by smaller and less lipid rich species in the GOA (Kimmel *et al.* 2019). The biomass of copepods and euphausiids were slightly below the long-term mean along the Seward Line (Danielson and Hopcroft 2019) and around Kodiak Island (Kimmel *et al.* 2019). In Icy Strait, northern southeast Alaska, the lipid content of all zooplankton taxa examined decreased, from 2018 to 2019, and were below average, except for euphausiids, indicating a decrease in the nutritional quality of the pretty field utilized by larval and juvenile fish (Fergusson 2019).

Predator population trends:

Rockfish are preyed on by a variety of other fish at all life stages, and to some extent by marine mammals during late juvenile and adult stages. Whether the impact of any particular predator is significant or dominant is unknown. Predator effects would likely be more important on larval, post-larval, and small juvenile shortraker rockfish, but information on these life stages and their predators is nil. Due to their large size, older shortraker rockfish likely have few potential predators other than very large animals such as sleeper sharks or sperm whales.

Changes in physical environment:

Strong year classes corresponding to the period around 1976-77 have been reported for many species of groundfish in the GOA, including Pacific ocean perch, northern rockfish, sablefish, and Pacific cod. Therefore, it appears that environmental conditions may have changed during this period in such a way that survival of young-of-the-year fish increased for many groundfish species, including slope rockfish. The environmental mechanism for this increased survival remains unknown. Changes in water temperature and currents could have an effect on prey item abundance and success of transition of rockfish from the pelagic to demersal stage. Rockfish in early juvenile stage have been found in floating kelp patches which would be subject to ocean currents.

Sea temperatures were at a record high for the entire GOA during the 2019 summer (Thoman and Walsh 2019). In nearshore waters above the continental shelf around Kodiak Island, temperatures were warmer through the water column during spring (6.8°C surface, 6.1°C bottom) and summer (13.3°C surface, 7.3°C bottom to 200 m) (Rogers *et al.* 2019). Summer and fall temperatures during 2019 indicate heat wave conditions similar to 2015-2016 in the GOA (Barbeaux 2019). It is reasonable to expect that the current heat wave may impact age-0 rockfish in pelagic waters during a time when they are growing to a size that promotes winter survival, but what this impact will be is unknown.

Changes in bottom habitat due to natural or anthropogenic causes could affect survival rates by altering available shelter, prey, or other functions. Associations of juvenile rockfish with biotic and abiotic structure have been noted by Carlson and Straty (1981), Pearcy *et al.* (1989), Love *et al.* (1991), and Freese and Wing (2003). A study in the GOA based on observations from a manned submersible found that adult "large" rockfish had a strong association with *Primnoa* spp. coral growing on boulders: less than 1 percent of the observed boulders had coral, but 85 percent of the "large" rockfish were next to boulders with coral (Krieger and Wing 2002). Although the "large" rockfish could not be positively identified, it is likely based on location and depth that many were shortraker rockfish. The Essential Fish Habitat Environmental Impact Statement (EFH EIS) for groundfish in Alaska (NMFS 2005) concluded that the effects of commercial fishing on the habitat of groundfish is minimal or temporary based largely on the criterion that stocks were above the Minimum Stock Size Threshold (MSST). However, a review of the EFH EIS suggested that this criterion was inadequate to make such a conclusion (Drinkwater 2004). The trend in shortraker abundance suggests that any adverse effect has not prevented the stock from increasing since 1990.

Fishery Effects on the Ecosystem

There is only a small amount of targeted fishing on shortraker rockfish in the GOA that is the result of "topping off" by trawlers (see subsection "Description of the Fishery"). Most of the catch in the GOA is taken incidentally in longline fisheries for sablefish and Pacific halibut or in the rockfish trawl fishery for Pacific ocean perch. Thus, the reader is referred to the discussions on "Fishery Effects" in the sablefish and Pacific ocean perch chapters in this SAFE report.

Fishery-specific contribution to bycatch of HAPC biota:

In the GOA, bottom trawl fisheries for shortraker and rougheye rockfish accounted for very little bycatch of HAPC biota (Table 11-9). This low bycatch is likely explained by the fact that little targeted fishing occurs for these fish.

Fishery-specific concentration of target catch in space and time relative to predator needs in space and time (if known) and relative to spawning components:

Unknown.

Fishery-specific effects on amount of large size target fish:

Unknown.

Fishery contribution to discards and offal production:

Annual fishery discard rates since 2011 have been 24-51% for shortraker rockfish. The discard amount of species other than shortraker rockfish in hauls targeting shortraker rockfish is unknown.

Fishery-specific effects on age-at-maturity and fecundity of the target fishery:

Unknown.

Fishery-specific effects on EFH non-living substrate:

Unknown, but the heavy-duty "rockhopper" trawl gear commonly used in the rockfish fishery can move around rocks and boulders on the bottom.

Data Gaps and Research Priorities

Currently, validation of aging methods for shortraker rockfish is the most important research priority so that an age-structured model can be used for assessment. Also, much additional research is needed on other aspects of shortraker rockfish biology and assessment. There is little to no information on larval, post-larval, or early stage juveniles of shortraker rockfish. In particular, information is lacking on juvenile shortraker rockfish, which are very seldom caught in any sampling gear. Habitat requirements for larval, post-larval, and early stages are mostly unknown. Habitat requirements for later stage juvenile and adult fish are mostly anecdotal or conjectural. While recent work has improved our understanding greatly (Du Preez and Tunnicliffe 2011, Laman *et al.* 2015), further research needs to be done on the bottom habitat of the fishing grounds, on what HAPC biota are found on these grounds, and on what impact bottom trawling has on the grounds. Investigation is needed on the distribution and abundance of shortraker rockfish in areas of rough bottom that cannot be sampled by trawl surveys.

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Tables

Table 11-1.--Estimated catch (%) of shortraker rockfish in the Gulf of Alaska by target fishery, 2005-2019.

	Target Fishery					
Year	Rockfish	Sablefish	Halibut	Pollock	Pacific Cod	Total*
2005	53	41	3	3	0	100
2006	47	35	5	12	1	100
2007	49	38	3	9	0	100
2008	44	39	4	12	1	100
2009	54	34	7	4	1	100
2010	31	64	2	2	1	100
2011	48	29	17	5	1	100
2012	45	46	7	2	1	100
2013	40	43	13	2	1	100
2014	35	33	18	<1	1	100
2015	41	43	10	1	1	100
2016	37	29	9	22	<1	100
2017	46	36	13	<1	1	100
2018	35	52	10	<1	1	100
2019	44	46	8	<1	<1	100

Source: National Marine Fisheries Service, Alaska Region, Catch Accounting System, accessed via the Alaska Fishery Information Network (AKFIN). Updated through October 1, 2019. * Numbers may not sum to 100 due to rounding.

Table 11-2.--A summary of key management measures and the time series of catch (t), ABC, TAC, and OFL for shortraker rockfish in the Gulf of Alaska.

Year	Catch (t)	ABC	TAC	OFL	Management Measures
1988					The NPFMC implements the slope rockfish assemblage, which includes shortraker rockfish and the species that will become “other slope rockfish”, together with Pacific ocean perch, northern rockfish, and rougheye rockfish. Previously, *Sebastes* in Alaska were managed as the “Pacific ocean perch complex” or “other rockfish”. Apportionment of ABC among management areas in the Gulf (Western, Central, and Eastern) for slope rockfish assemblage is determined based on average percent biomass in previous NMFS trawl surveys.
1989		2,092	2,092		
1990					
1991	702	2,000	2,000		Slope rockfish assemblage is split into three management subgroups with separate ABCs and TACs: Pacific ocean perch, shortraker/rougheye rockfish, and “other slope rockfish”.
1992	2,165	1,960	1,960		
1993	1,932	1,960	1,764		
1994	1,832	1,960	1,960		
1995	2,250	1,910	1,910		
1996	1,661	1,910	1,910		
1997	1,609	1,590	1,590		Area apportionment procedure for shortraker/rougheye is changed. Apportionment is now based on 4:6:9 weighting of biomass in the most recent three NMFS trawl surveys.
1998	1,734	1,590	1,590		
1999	1,311	1,590	1,590		Trawling is prohibited in the Eastern Gulf east of 140 degrees W longitude. Eastern Gulf trawl closure becomes permanent with the implementation of FMP Amendments 41 and 58 in 2000 and 2001, respectively.
2000	1,745	1,730	1,730	2,513	
2001	1,976	1,730	1,730	2,513	
2002	1,323	1,620	1,620	2,343	
2003	1,402	1,620	1,620	2,343	
2004	997	1,318	1,318	2,512	
2005	501	753	753	982	Shortraker rockfish is split as a separate management entity from rougheye rockfish and now has its own ABC and TAC.
2006	747	843	843	1,124	
2007	680	843	843	1,124	Amendment 68 creates the Central Gulf Rockfish Pilot Program, which affects trawl catches of rockfish in this area.
2008	607	898	898	1,197	
2009	562	898	898	1,197	
2010	499	914	914	1,219	
2011	552	914	914	1,219	
2012	687	1,081	1,081	1,441	The Central Gulf Rockfish Program is permanently put into place.

Table 11-2. -- cont.

Year	Catch (t)	ABC	TAC	OFL	Management Measures
2013	731	1,081	1,081	1,441	
2014	692	1,323	1,323	1,764	
2015	577	1,323	1,323	1,764	
2016	779	1,286	1,286	1,715	
2017	553	1,286	1,286	1,715	
2018	763	863	863	1,151	Estimation of exploitable biomass and area apportionment procedures for shortraker is changed. Apportionment is now based on applying the time series of trawl survey data to a random effects model.
2019	536	863	863	1,151	

Source: National Marine Fisheries Service, Alaska Region, Catch Accounting System, accessed via the Alaska Fishery Information Network (AKFIN). Updated through October 1, 2019.

Table 11-3.--Commercial catch (t) of fish in the shortraker/rougheye rockfish and shortraker rockfish management categories in the Gulf of Alaska, with Gulfwide values of acceptable biological catch (ABC) and total allowable catch (TAC), 1991-2019. Updated through October 1, 2019.

	Area of Gulf			Gulfwide	Gulfwide	Gulfwide
Year	Western	Central	Eastern	total	ABC	TAC
			Shortraker/Rougheye Rockfish			
1991	123	408	171	702	2,000	2,000
1992	115	1,367	683	2,165	1,960	1,960
1993	85	1,197	650	1,932	1,960	1,764
1994	114	996	722	1,832	1,960	1,960
1995	216	1,222	812	2,250	1,910	1,910
1996	127	941	593	1,661	1,910	1,910
1997	137	931	541	1,609	1,590	1,590
1998	129	870	735	1,734	1,590	1,590
1999	194	580	537	1,311	1,590	1,590
2000	137	887	721	1,745	1,730	1,730
2001	126	998	852	1,976	1,730	1,730
2002	263	631	429	1,323	1,620	1,620
2003	225	856	321	1,402	1,620	1,620
2004	277	337	383	997	1,318	1,318
			Shortraker Rockfish			
2005	71	224	205	501	753	753
2006	91	336	319	747	843	843
2007	194	214	272	680	843	843
2008	134	238	235	607	898	898
2009	152	189	221	562	898	898
2010	72	132	295	499	914	914
2011	81	243	228	552	914	914
2012	90	304	294	687	1,081	1,081
2013	37	449	245	731	1,081	1,081
2014	77	328	287	692	1,323	1,323
2015	47	261	269	577	1,323	1,323
2016	53	422	305	779	1,286	1,286
2017	43	232	277	553	1,286	1,286
2018	38	325	400	763	863	863
2019	27	154	355	536	863	863

Sources: Catch: 1991-2019: National Marine Fisheries Service, Alaska Region, Catch Accounting System, accessed via the Alaska Fishery Information Network (AKFIN). Updated through October 1, 2019. ABC and TAC: 1991-2007, Clausen (2007); 2008 - 2019, North Pacific Fishery Management Council website (http://www.fakr.noaa.gov/npfmc/Council0910specs.pdf).

Table 11-4.--Estimated commercial catch (t) of shortraker rockfish in the Gulf of Alaska, 1993-2003, based on data from the NMFS Alaska Observer Program database and from the NMFS Alaska Regional Office. See Clausen (2004) for an explanation of how these numbers were estimated.

Year	Catch
1993	1,348
1994	1,254
1995	1,545
1996	1,102
1997	1,065
1998	1,069
1999	992
2000	1,214
2001	1,385
2002	1,051
2003	1,010

Table 11-5.-- Gulf of Alaska shortraker rockfish retained (t) and discarded (t) by target fishery, and total Gulfwide discard rate, 2005 – 2019; approximate percentage of total discards in parentheses. 2005-2019: National Marine Fisheries Service, Alaska Region, Catch Accounting System, accessed via the Alaska Fishery Information Network (AKFIN). Updated through October 1, 2019.

	Halibut		Pollock-nonpelagic		Rockfish		Sablefish		Gulfwide Total
Year	Retained	Discarded	Retained	Discarded	Retained	Discarded	Retained	Discarded	Discard Rate
2005	30	1 (4%)	1	0 (0%)	239	10 (4%)	126	64 (34%)	16.0%
2006	52	109 (68%)	6	0 (0%)	266	8 (3%)	112	91 (45%)	31.7%
2007	61	26 (30%)	1	0 (0%)	283	8 (3%)	98	130 (57%)	25.8%
2008	77	9 (10%)	17	0 (0%)	219	13(6%)	120	83 (41%)	20.2%
2009	73	29 (29%)	14	0 (0%)	207	41(16%)	83	72 (46%)	28.8%
2010	69	2 (3%)	1	0 (0%)	121	10 (8%)	119	155 (57%)	35.4%
2011	45	22 (32%)	15	0 (0%)	213	28 (12%)	77	54 (41%)	24.0%
2012	37	9 (20%)	<1	0 (0%)	279	25 (8%)	130	176 (58%)	32.2%
2013	40	53 (57%)	2	0 (0%)	247	42 (15%)	93	220 (70%)	44.3%
2014	33	90 (73%)	<1	0 (0%)	238	5 (2%)	92	139 (60%)	36.0%
2015	34	25 (43%)	2	0 (0%)	235	3 (1%)	95	155 (62%)	32.8%
2016	30	38 (56%)	<1	143 (100%)	276	15 (5%)	63	166 (73%)	51.2%
2017	25	48 (66%)	<1	0	228	26 (10%)	62	137 (69%)	39.6%
2018	26	53 (67%)	<1	0	244	24 (9%)	64	330 (84%)	55.8%
2019	22	18 (44%)	0	0	216	20 (9%)	63	181 (74%)	42.7%

Table 11-6.--Relative population number (RPN) and relative population weight (RPW) with the associated coefficient of variation (CV) for Gulf of Alaska shortraker rockfish in the Alaska Fishery Science Center longline survey, 1992-2019. Data are for the upper continental slope only, 201-1,000 m depth (gullies are not included): Western Gulf of Alaska (WG), Central Gulf of Alaska (CG), West Yakutat (WY), and East Yakutat/Southeast Outside (EY/SE).

			RPN		Gulfwide			RPW *		Gulfwide	
Year	WG	CG	WY	EY/SE	Total	WG	CG	WY	EY/SE	Total	CV
1992	1,330	1,891	4,285	5,144	12,650	1,735	3,212	9,791	5,481	20,219	18%
1993	3,508	2,447	3,787	5,531	15,274	2,103	5,297	7,425	6,544	21,368	23%
1994	4,458	3,316	3,973	9,031	20,778	3,718	3,346	5,471	6,478	19,013	14%
1995	5,765	1,856	3,714	6,705	18,039	7,288	2,924	8,022	8,033	26,267	13%
1996	4,102	2,878	4,990	5,383	17,352	5,428	5,036	10,966	9,144	30,574	14%
1997	2,888	3,119	7,984	6,891	20,881	4,143	4,933	18,968	10,788	38,832	16%
1998	4,642	3,481	8,355	10,198	26,677	6,268	5,814	15,265	13,316	40,662	12%
1999	5,012	3,902	6,326	10,237	25,476	6,380	5,883	11,650	12,188	36,101	11%
2000	9,550	4,202	9,806	8,214	31,772	13,795	6,218	19,797	13,422	53,232	13%
2001	5,150	4,734	8,335	8,488	26,706	6,699	8,263	19,674	9,615	44,251	19%
2002	3,405	2,932	3,819	9,221	19,377	4,693	4,460	10,361	11,273	30,788	15%
2003	3,576	2,319	3,582	7,680	17,157	5,525	4,167	9,208	10,342	29,242	14%
2004	6,477	1,883	5,162	5,231	18,754	9,282	2,716	9,908	8,852	30,758	21%
2005	2,041	2,081	4,271	4,597	12,990	3,126	3,214	10,142	6,604	23,086	15%
2006	3,901	4,011	4,013	6,063	17,989	5,650	6,233	7,919	6,916	26,718	14%
2007	3,566	4,914	7,784	8,260	24,524	4,629	8,224	14,948	11,309	39,110	12%
2008	3,349	4,561	8,245	6,808	22,964	5,684	6,590	14,910	8,211	35,396	12%
2009	4,327	6,515	6,964	5,452	23,258	5,608	12,407	11,960	6,717	36,691	18%
2010	4,529	3,149	3,776	4,305	15,759	6,328	4,664	7,306	5,391	23,688	15%
2011	8,188	5,258	4,267	5,664	23,377	10,808	8,135	7,404	7,867	34,215	17%
2012	3,663	4,218	4,390	5,388	17,659	5,212	6,024	10,838	7,393	29,468	13%
2013	3,959	3,314	2,867	4,559	14,699	5,136	4,726	5,395	5,959	21,217	14%
2014	2,826	5,076	7,580	4,974	20,456	3,955	7,698	16,179	7,203	35,035	13%
2015	3,359	4,240	6,592	5,305	19,496	4,456	5,497	15,335	8,187	33,475	13%
2016	3,320	4,631	3,295	3,188	14,434	5,505	6,456	8,531	4,145	24,638	16%
2017	5,728	5,462	3,626	5,195	20,011	7,426	7,676	5,698	6,631	27,431	13%
2018	3,685	4,359	3,879	3,571	15,493	4,432	6,042	8,233	4,869	23,576	18%
2019	4,803	4,035	4,344	4,140	17,323	6,848	5,696	9,273	5,065	26,882	21%

Source: 1992-2019: D. Hanselman, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Pt. Lena Loop Rd., Juneau AK 99801. Pers. commun. October 15, 2019.
*RPW values are calculated using the most recent calculated geographic area sizes for the AFSC longline survey (Echave *et al.* 2013).

Table 11-7.--Biomass estimates (t) for shortraker rockfish in the Gulf of Alaska, by statistical area, based on bottom trawl surveys conducted between 1984 and 2019. Gulfwide 95% confidence bounds, variance, and coefficient of variation (CV) are also shown for each year.

	Statistical areas						Gulfwide			
							95% Conf. bounds			
Year	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Gulfwide Total	Lower	Upper	Biomass variance	Biomass CV (%)
					Shortraker Rockfish					
1984	4,874	659	4,685	6,288	2,051	18,557	4,600	32,515	34,829,252	31.8
1987	3,232	13,182	18,950	4,408	3,079	42,851	13,392	72,311	196,602,336	32.7
1990	284	1,729	3,027	6,037	1,604	12,681	6,412	18,951	9,085,499	23.8
1993	2,775	2,320	4,735	7,740	1,903	19,472	11,290	27,654	15,474,771	20.2
1996	1,905	2,406	7,726	4,523	3,699	20,258	10,652	29,865	20,532,868	22.4
1999	2,208	3,931	8,459	9,831	3,845	28,275	16,841	39,709	30,393,883	19.5
2001*	4,313	1,589	11,513	7,350	3,149	27,914	18,819	37,008	21,530,717	16.6
2003	11,166	2,996	14,292	11,936	1,633	42,023	23,572	60,474	81,168,454	21.4
2005	5,946	6,342	10,741	16,866	2,673	42,575	25,603	59,532	69,018,739	19.5
2007	2,492	1,911	8,275	8,197	14,250	35,125	17,296	52,954	66,950,870	23.3
2009	8,810	3,209	13,541	12,518	6,109	44,185	25,332	63,039	79,840,212	20.2
2011	2,464	23,784	9,113	22,561	7,316	65,237	18,028	111,643	461,441,570	33.1
2013	2,248	2,410	6,318	49,374	7,021	67,370	13,999	120,740	535,643,928	34.4
2015	1,064	4,881	9,191	32,662	14,520	62,317	19,200	105,433	404,045,782	32.3
2017	2,542	1,595	12,197	13,228	1,973	31,534	14,518	48,550	73,372,223	27.5
2019	431	5,700	11,967	20,473	6,203	44,773	20,115	69,431	158,269,748	28.1

*The 2001 survey did not sample the eastern Gulf of Alaska (Yakutat and Southeastern areas). Substitute estimates of biomass for these areas in 2001 were obtained by averaging the Yakutat and Southeastern biomass in the 1993, 1996, and 1999 surveys. These eastern Gulf of Alaska estimates have been included in the 2001 biomass estimates, confidence bounds, biomass variances, and biomass CVs listed in this table.

Table 11-8.-- Analysis of ecosystem considerations for shortraker rockfish.

Indicator	***Observation***	***Interpretation***	***Evaluation***
ECOSYSTEM EFFECTS ON STOCK			
Prey availability or abundance trends	important for larval and post-larval survival, but no information known	may help to determine year class strength	possible concern
Predator population trends	unknown		little concern for adults
Changes in habitat quality	variable	variable recruitment	possible concern
FISHERY EFFECTS ON ECOSYSTEM			
Fishery contribution to bycatch			
Prohibited species	unknown		
Forage (including herring, Atka mackerel, cod, and pollock)	unknown		
HAPC biota (seapens/whips, corals, sponges, anemones)	fishery disturbing hard-bottom biota, i.e., corals, sponges	could harm the ecosystem by reducing shelter for some species	concern
Marine mammals and birds	probably few taken		little concern
Sensitive non-target species	unknown		
Fishery concentration in space and time	little overlap between fishery and reproductive activities	fishery does not hinder reproduction	little concern
Fishery effects on amount of large size target fish	unknown		
Fishery contribution to discards and offal production	discard rates moderate	some unnatural input of food into the ecosystem	some concern
Fishery effects on age-at-maturity and fecundity	unknown		

Table 11-9.--Average bycatch (kg) and bycatch rates during 1997 - 99 of living substrates in the Gulf of Alaska; POT - pot gear; BTR - bottom trawl; HAL - Hook and line (source - Draft Programmatic SEIS).

		Bycatch (kg)				Target	Bycatch rate (kg/t target)			
Target fishery	Gear	Coral	Anemone	Sea whips	Sponge	catch (t)	Coral	Anemone	Sea whips	Sponge
Arrowtooth flounder	POT	0	0	0	0	4	0.0000	0.0000	0.0000	0.0000
Arrowtooth flounder	BTR	58	99	13	24	2,097	0.0276	0.0474	0.0060	0.0112
Deep water flatfish	BTR	1,626	481	5	733	2,001	0.8124	0.2404	0.0024	0.3663
Rex sole	BTR	321	306	11	317	2,157	0.1488	0.1417	0.0053	0.1468
Shallow water flatfish	POT	0	0	0	0	5	0.0000	0.0000	0.0000	0.0000
Shallow water flatfish	BTR	53	4,741	115	403	2,024	0.0261	2.3420	0.0567	0.1993
Flathead sole	BTR	3	267	1	136	484	0.0071	0.5522	0.0019	0.2806
Pacific cod	HAL	28	4,419	961	33	10,765	0.0026	0.4105	0.0893	0.0030
Pacific cod	POT	0	14	0	1,724	12,863	0.0000	0.0011	0.0000	0.1340
Pacific cod	BTR	34	5,767	895	788	37,926	0.0009	0.1521	0.0236	0.0208
Pollock	BTR	1,153	55	0	23	2,465	0.4676	0.0222	0.0000	0.0092
Pollock	PTR	41	110	0	0	97,171	0.0004	0.0011	0.0000	0.0000
Demersal shelf rockfish	HAL	0	0	0	141	226	0.0000	0.0000	0.0000	0.6241
Northern rockfish	BTR	25	90	0	103	1,938	0.0127	0.0464	0.0000	0.0532
Other slope rockfish	HAL	0	0	0	0	14	0.0000	0.0000	0.0000	0.0000
Other slope rockfish	BTR	0	0	0	0	193	0.0000	0.0000	0.0000	0.0000
Pelagic shelf rockfish	HAL	0	0	0	0	203	0.0000	0.0000	0.0000	0.0000
Pelagic shelf rockfish	BTR	324	176	3	245	1,812	0.1788	0.0969	0.0017	0.1353
Pacific ocean perch	BTR	549	90	5	1,968	6,564	0.0837	0.0136	0.0007	0.2999
Pacific ocean perch	PTR	7	0	0	55	1,320	0.0052	0.0000	0.0000	0.0416
Shortraker/rougheye	HAL	6	0	0	0	19	0.3055	0.0000	0.0000	0.0000
Shortraker/rougheye	BTR	0	18	0	0	21	0.0000	0.8642	0.0000	0.0000
Sablefish	HAL	156	154	68	27	11,143	0.0140	0.0138	0.0061	0.0025
Sablefish	BTR	0	0	0	0	27	0.0000	0.0000	0.0000	0.0000
Shortspine thornyhead	HAL	0	0	0	0	2	0.0000	0.0000	0.0000	0.0000
Shortspine thornyhead	BTR	0	9	0	1	2	0.0000	4.8175	0.0000	0.4069

Figures

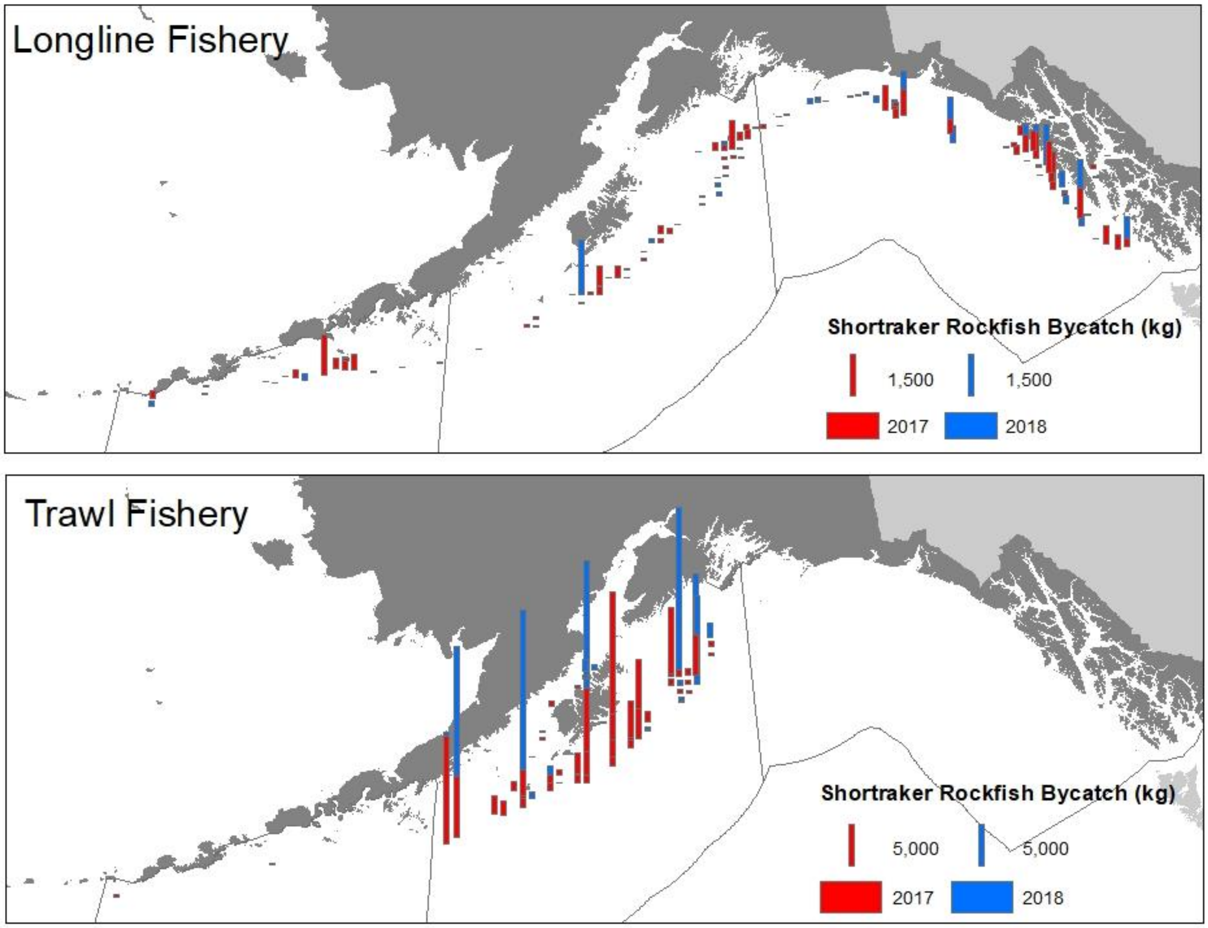

Figure 11-1.-- Spatial distribution of observed shortraker rockfish catch in the Gulf of Alaska from 2017 (red bars) and 2018 (blue bars) in the longline fishery (top panel) and trawl fishery (bottom panel). Height of the bar represents the catch in kilograms. Each bar represents non-confidential catch data summarized into 400 km2 grids. Grid blocks with zero catch were not included for clarity. Data provided by the

Fisheries Monitoring and Analysis division website, queried October 15, 2019 (http://www.afsc.noaa.gov/FMA/spatial_data.htm).

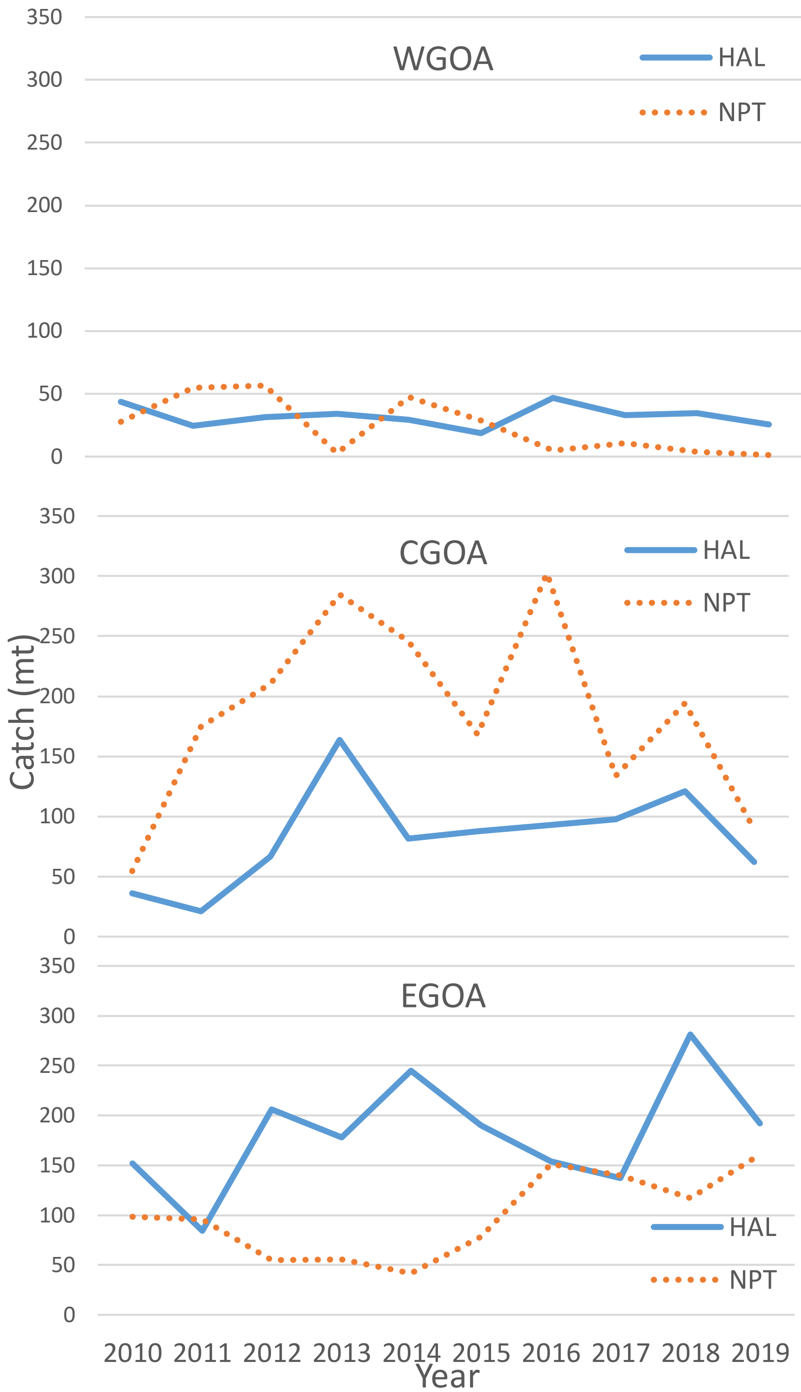

Figure 11-2.--Catch (t) of shortraker rockfish by gear type, area and year. Gear type: hook and line (HAL) and nonpelagic trawl (NPT). Area: western Gulf of Alaska (WGOA), central Gulf of Alaska (CGOA), and eastern Gulf of Alaska (EGOA).

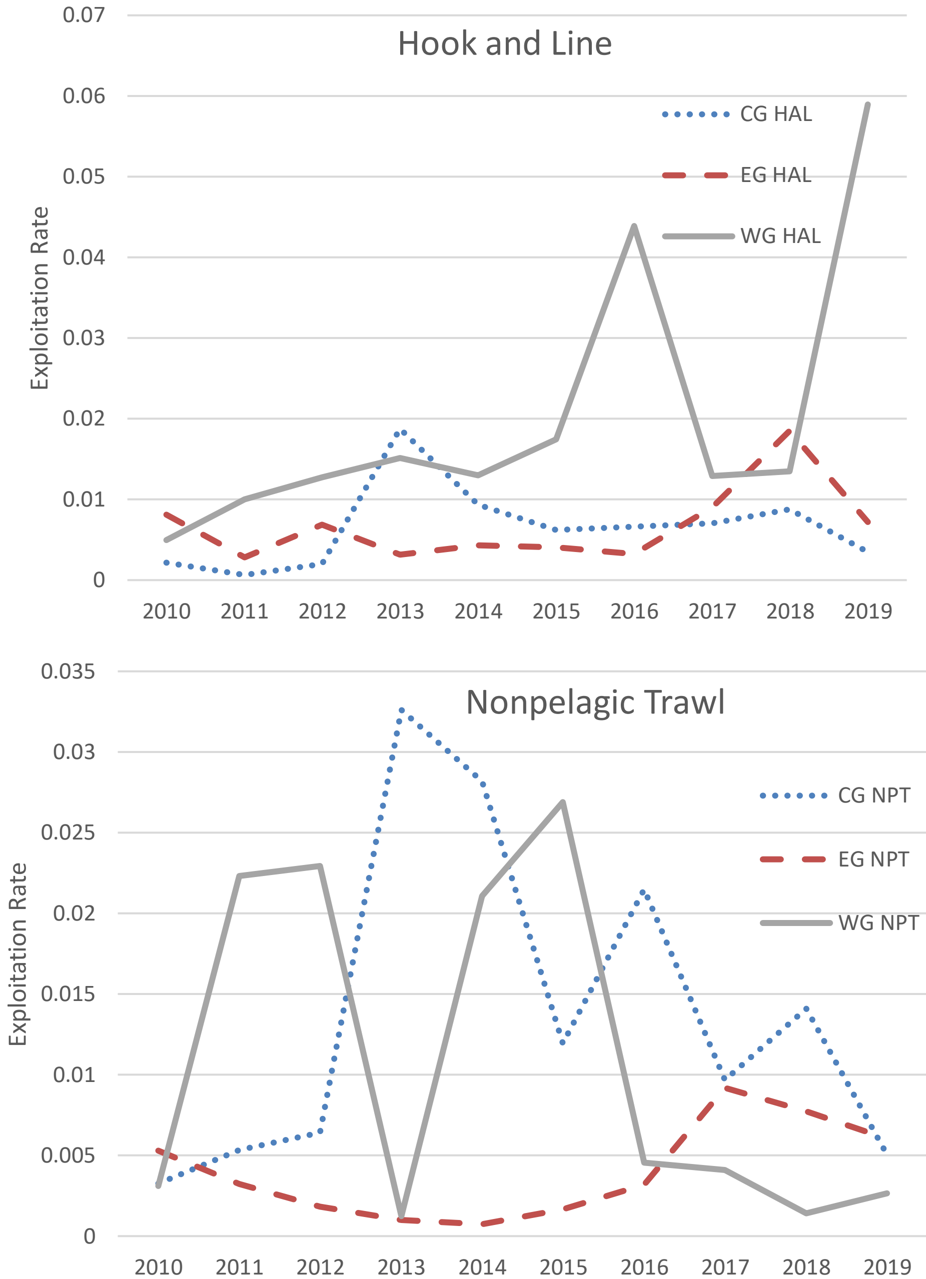

Figure 11-3.--Time series of the exploitation rates of shortraker rockfish in the observed hook and line (HAL) fishery (top panel) and the nonpelagic trawl (NPT) fishery (bottom panel), by area [central Gulf of Alaska (CG), eastern Gulf of Alaska (EG), and western Gulf of Alaska (WG)].

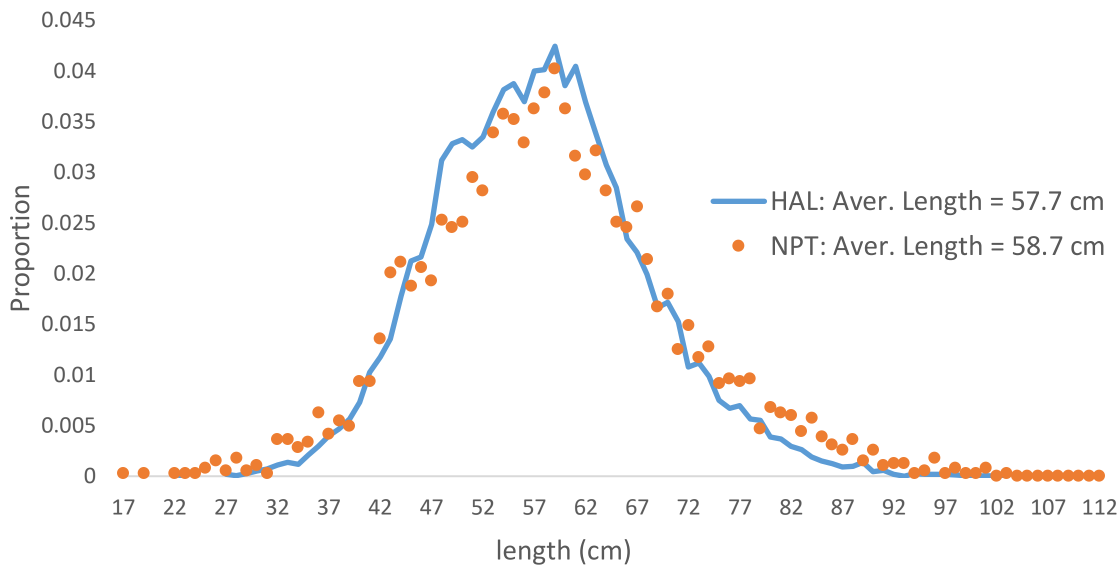

Figure 11-4.--Length frequencies as observed in the hook and line (HAL; solid blue line) and the nonpelagic trawl (NPT; orange dots) fisheries, 2005 – 2019 years combined.

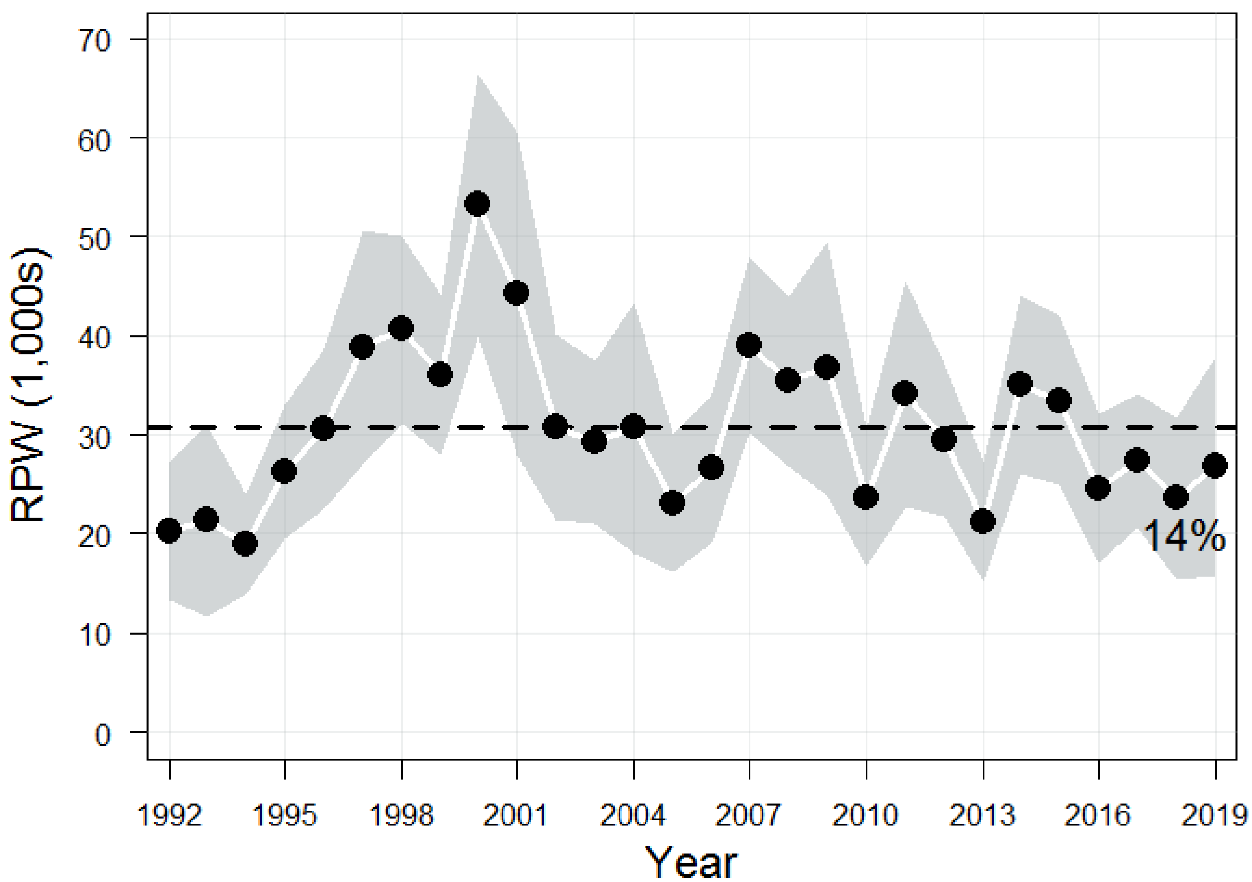

Figure 11-5.--Time series of the relative population weights (RPW, 1,000s) of Gulf of Alaska (GOA) shortraker rockfish caught on the longline survey with 95% confidence intervals. Dashed line depicts the histrorical average. The 2019 RPW value is up 14% from 2018.

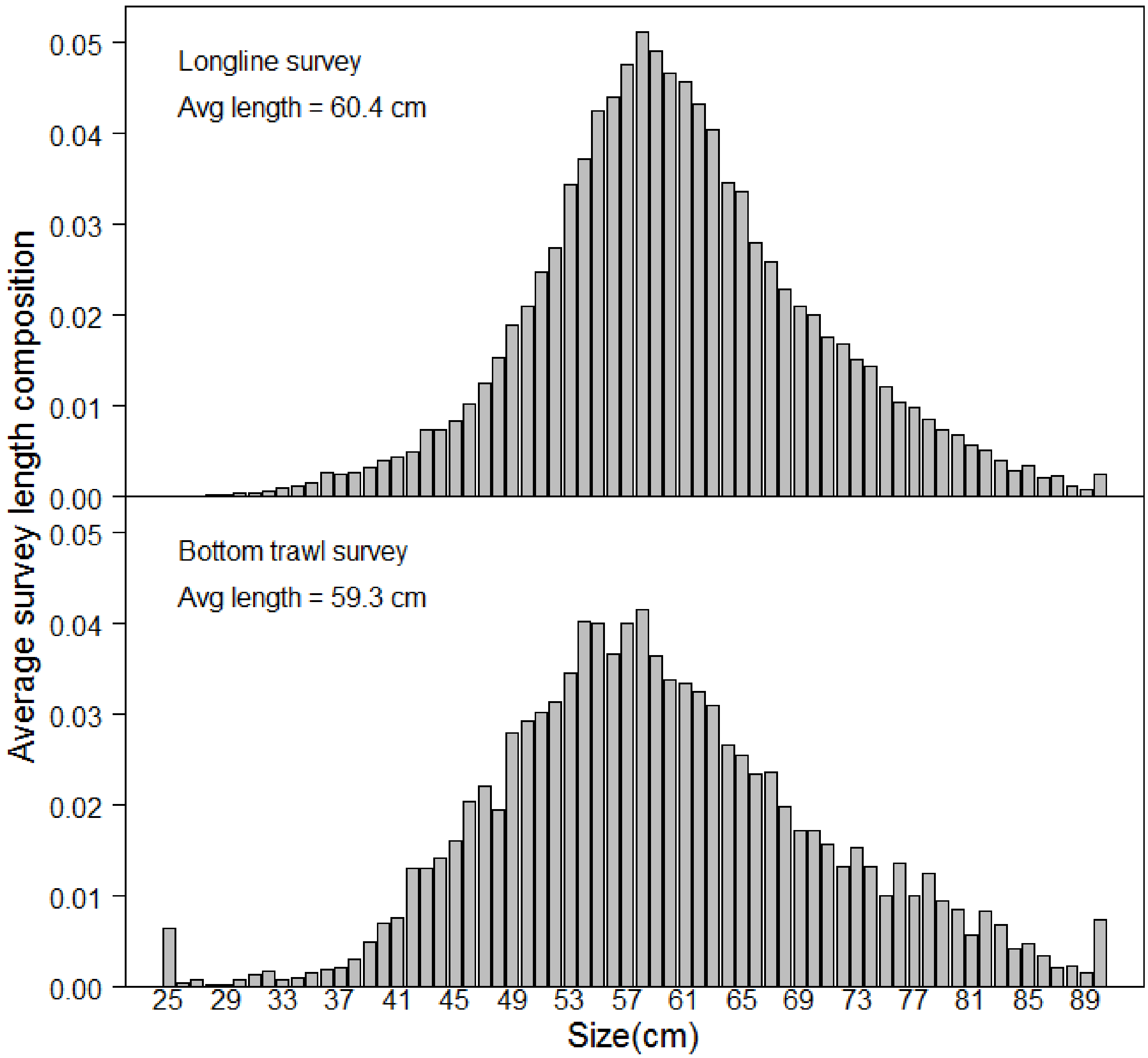

Figure 11-6.—Average length frequency distribution across years of shortraker rockfish caught on the domestic longline survey (top panel) and bottom trawl survey (bottom panel).

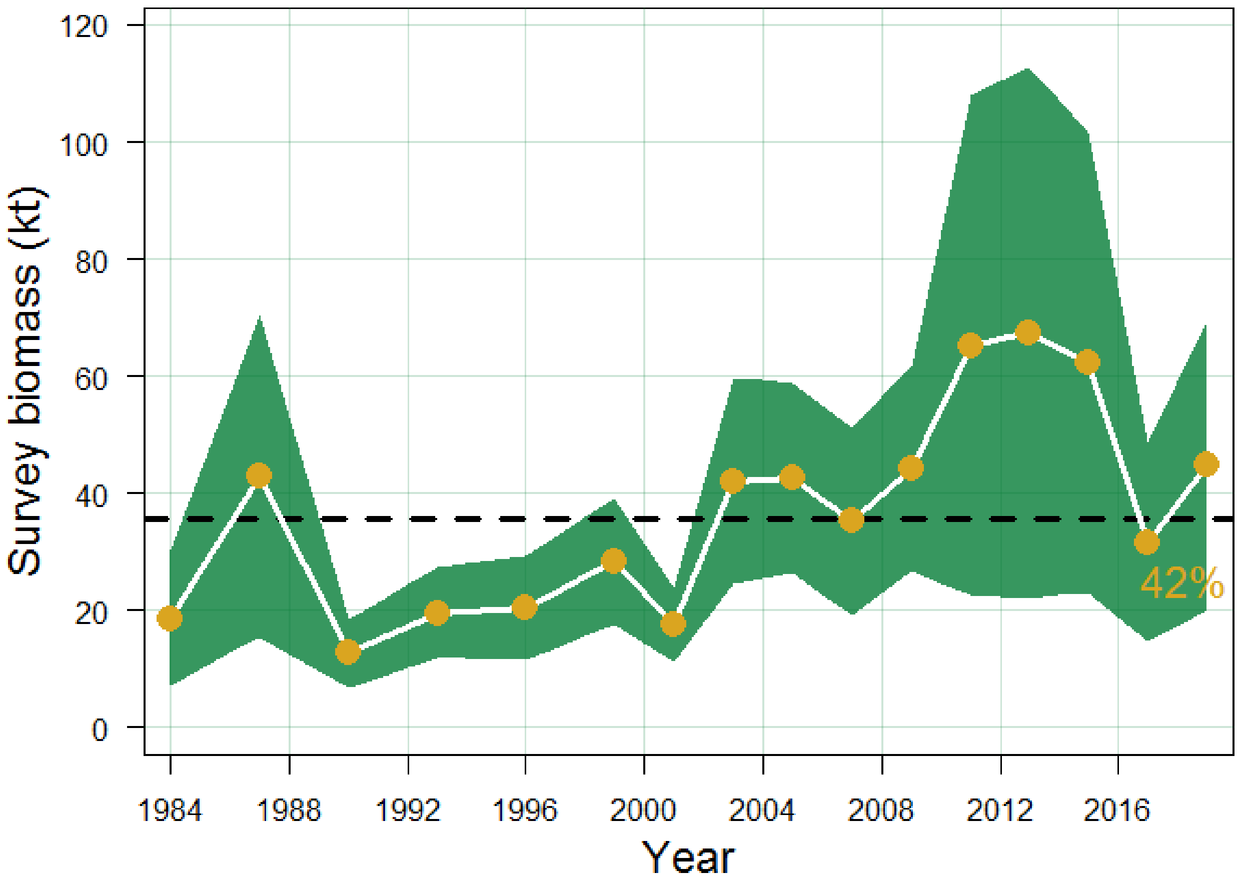

Figure 11-7.-- Estimated biomass (t) of shortraker rockfish in the Gulf of Alaska based on results of bottom trawl surveys from 1984 through 2019 with 95% confidence intervals. The eastern Gulf of Alaska was not sampled in the 2001 survey, but substitute estimates of biomass and confidence limits for this region in 2001 were calculated and included in the above graph. Dashed line depicts the histrorical average. The 2019 estimated biomass value is up 42% from 2017.

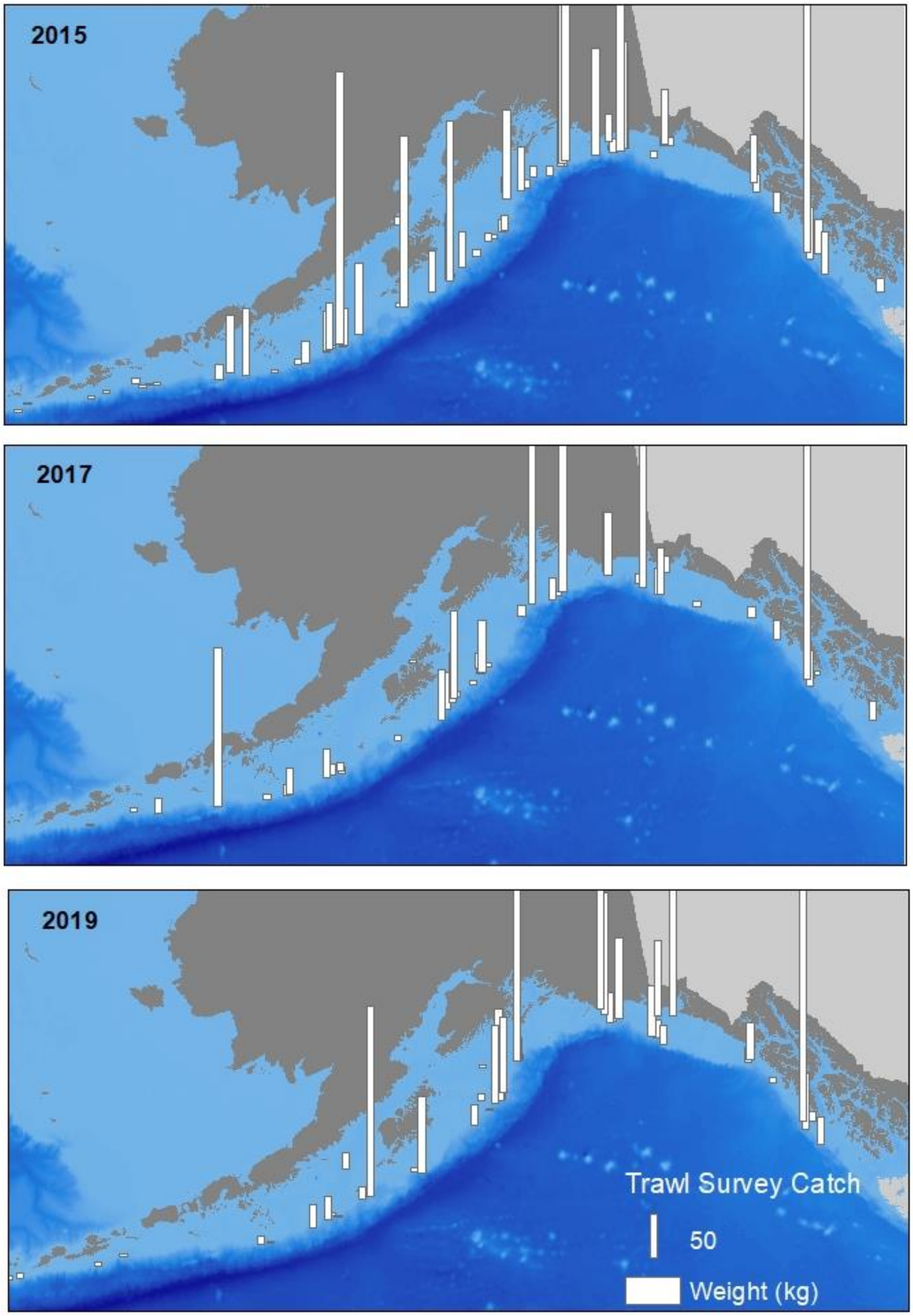

Figure 11-8.--Spatial distribution of shortraker rockfish catches (in weight, kg) in the Gulf of Alaska during the 2015, 2017, and 2019 NMFS bottom trawl surveys.

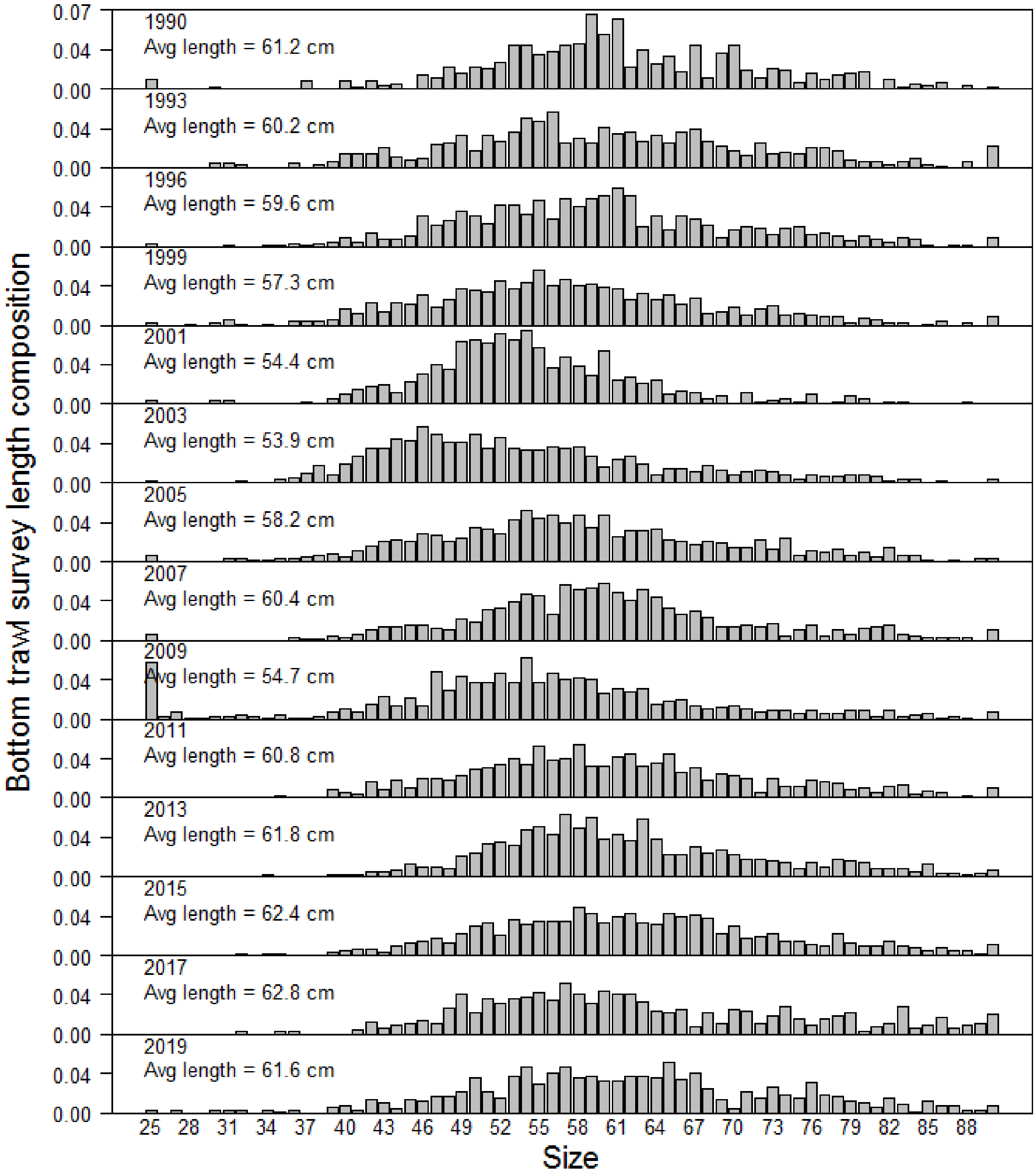

Figure 11-9.--Size composition of the estimated population of shortraker rockfish in the Gulf of Alaska based on trawl surveys conducted between 1990 and 2019.

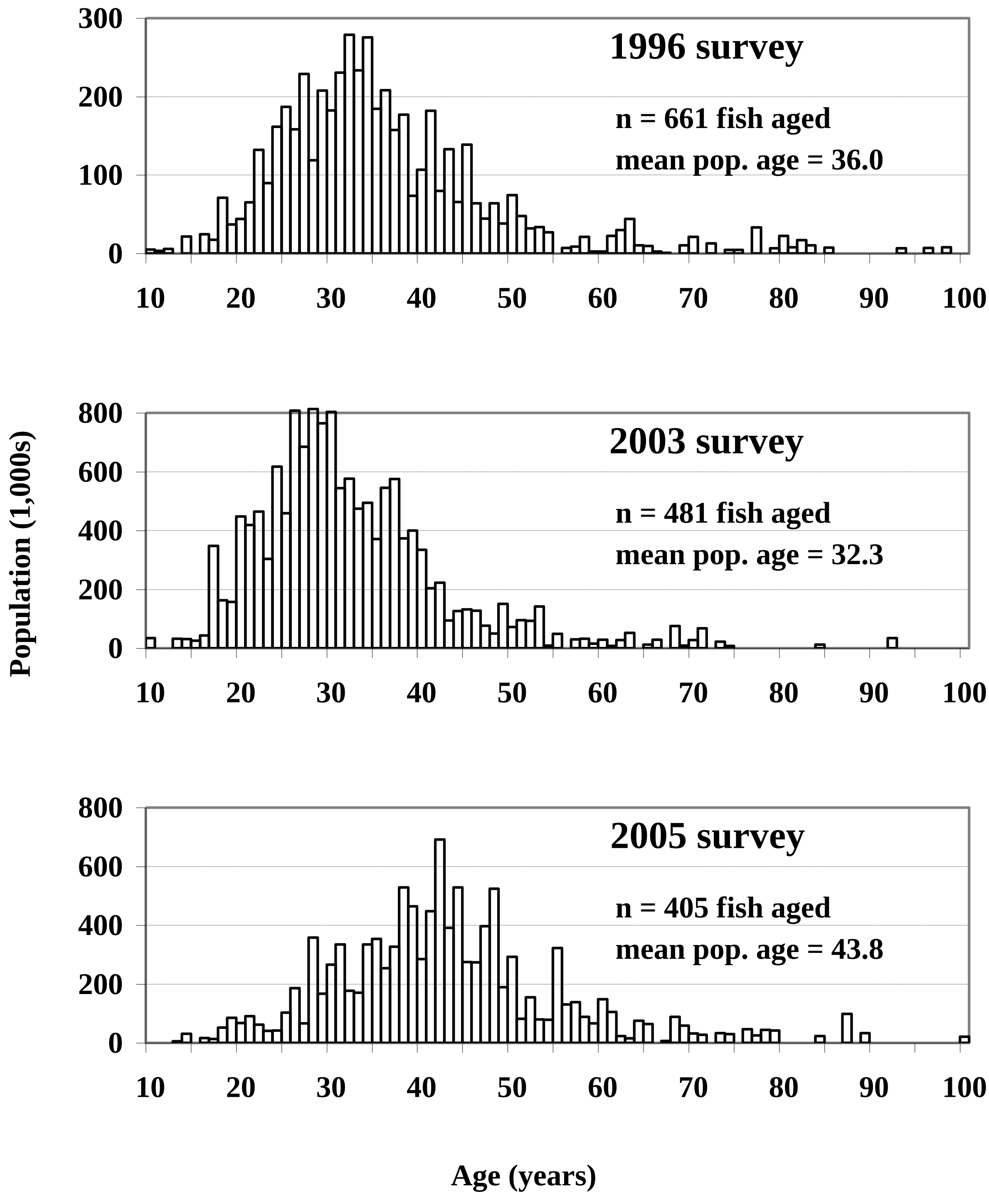

Figure 11-10.--Age composition of the estimated population of shortraker rockfish in the 1996, 2003, and 2005 Gulf of Alaska trawl surveys.

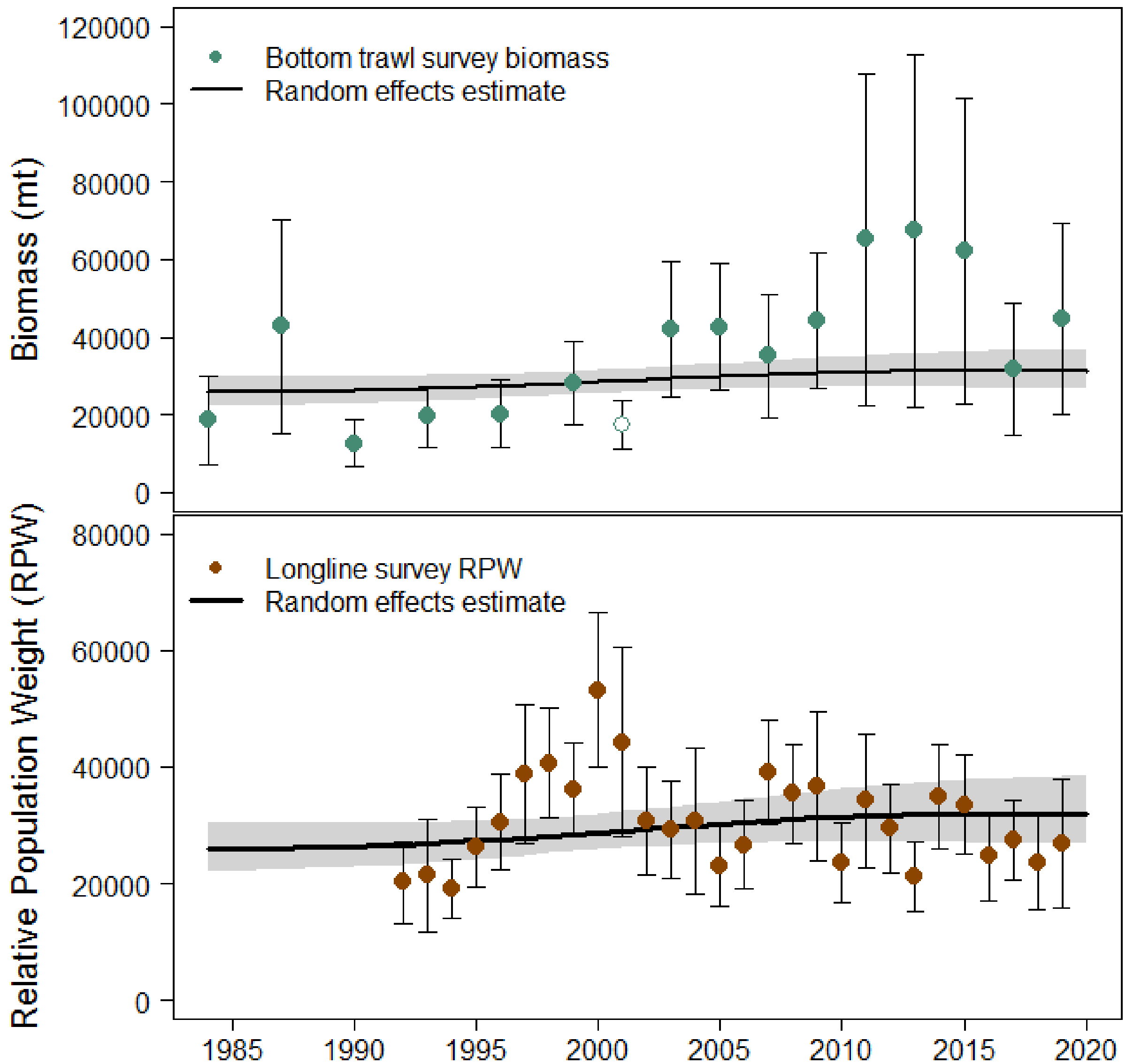

Figure 11-11.--Biomass estimates (t, top panel) of shortraker rockfish from the random effects model (solid black line with 95% confidence interval in grey shaded region) for the AFSC bottom trawl survey (1984-2019, filled circle with error bars for 95% confidence intervals, open circles denotes years with missing regional data), and Relative Population Weight estimates (RPW, lower panel) from the random effects model (solid black line with 95% confidence interval in grey shaded region) for the AFSC longline survey (filled circle with error bars for 95% confidence intervals).

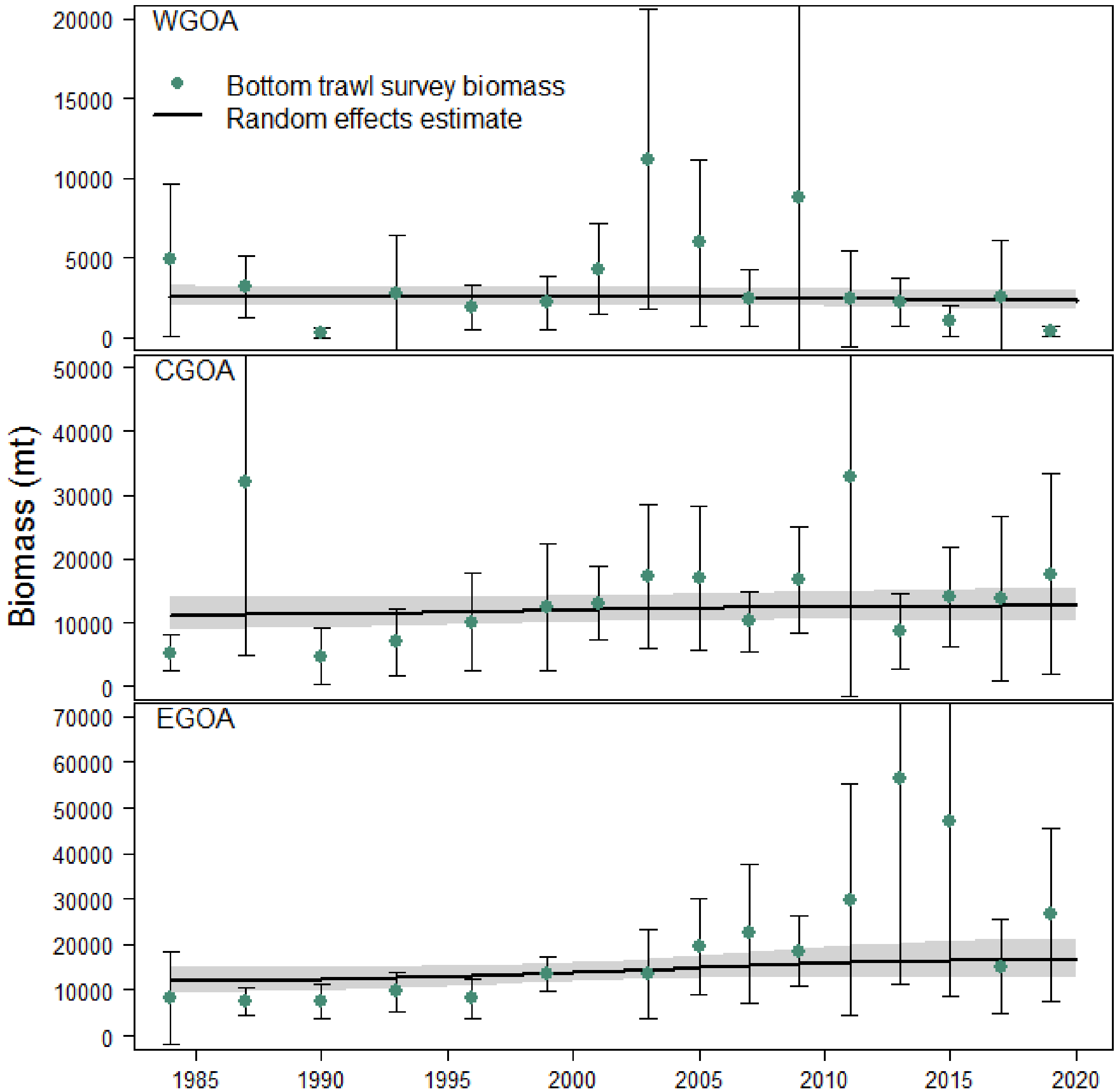

Figure 11-12.-- Biomass estimates (t) of shortraker rockfish by area from NMFS bottom trawl surveys (filled circle) and from a random effects model (solid black line with grey region denoting 95% confidence interval) that utilizes trawl survey biomass estimates from all years (1984 – 2019, with 95% sampling error confidence intervals shown with error bars). Top panel is the Western Gulf of Alaska (WGOA) Area, middle panel is the Central Gulf of Alaska (CGOA) Area, and bottom panel is the Eastern Gulf of Alaska (EGOA) Area. Please note the different scales between panels on the y-axis.

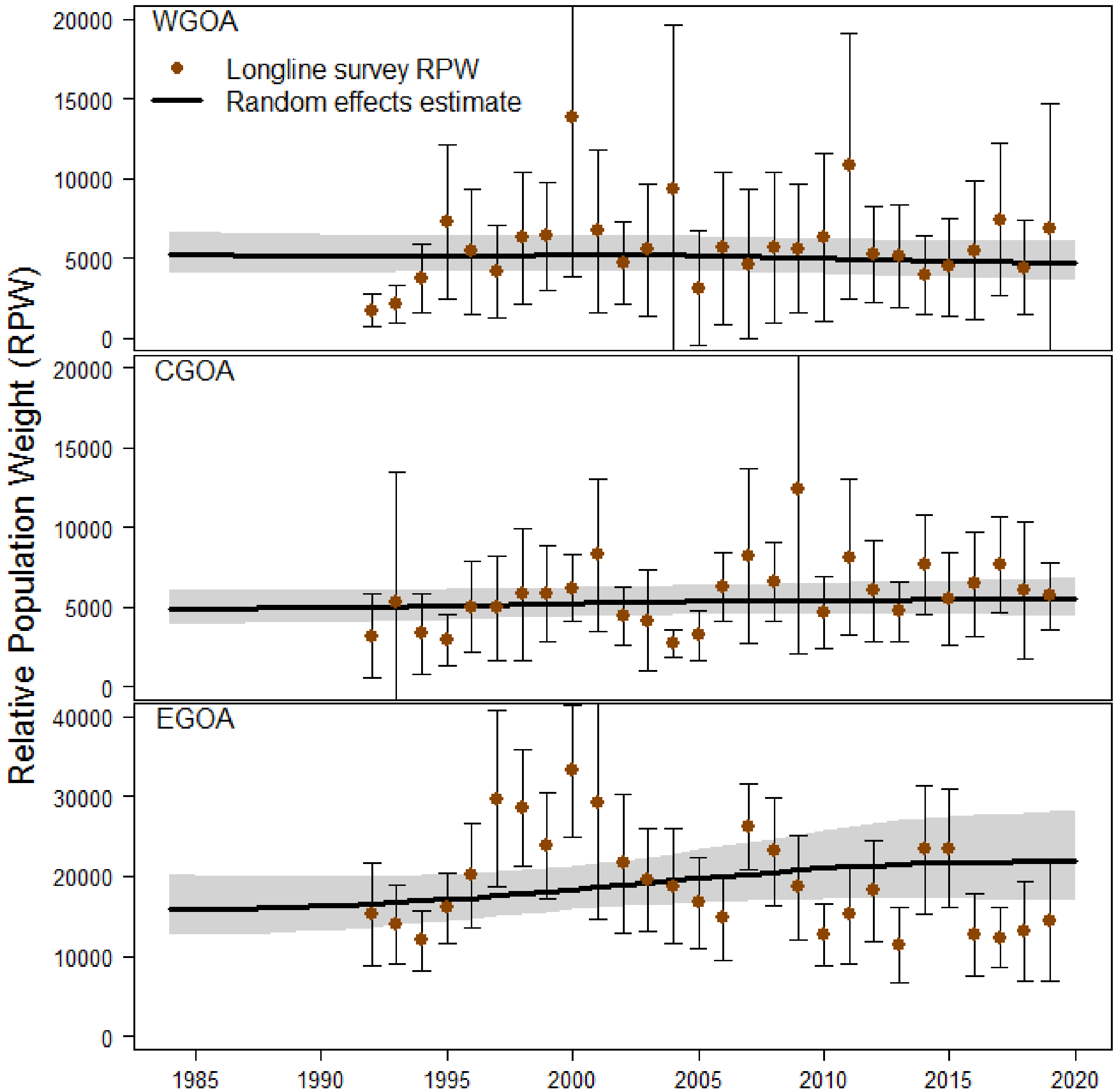

Figure 11-13.-- Relative Population Weight (RPW) of shortraker rockfish by area from AFSC longline surveys (1992-2019, filled circle with error bars for the 95% confidence intervals) fit to the recommended random effects model (solid black line with 95% confidence intervals shown in grey shaded region). Please note the different scales between panels on the y-axis.

Appendix 11A – Supplemental Catch Data

In order to comply with the Annual Catch Limit (ACL) requirements, non-commercial removals in the Gulf of Alaska (GOA) are presented. Non-commercial removals are estimated total removals that do not occur during directed groundfish fishing activities (Table 11A-1). This includes removals incurred during research, subsistence, personal use, recreational, and exempted fishing permit activities, but does not include removals taken in fisheries other than those managed under the groundfish FMP. These estimates represent additional sources of removals to the existing Catch Accounting System estimates.

Research catches of shortraker rockfish for the years 1977-2018 are listed in Table 11A-2. Although data are not available for a complete accounting of all research catches, the values in the table indicate that generally these catches have been modest. The one exception is 1999, when a total of almost 110 t was taken, mostly by research trawling. The majority of research removals of shortraker rockfish are taken by the Alaska Fisheries Science Center's (AFSC) annual longline survey and the biennial bottom trawl survey, which are the primary research surveys used for assessing the population status of GOA shortraker rockfish. Other research activities that harvest minor amounts of shortraker rockfish include other trawl research activities conducted by the Alaska Department of Fish and Game (ADFG) and the International Pacific Halibut Commission's (IPHC) longline survey. Recorded recreational harvest or harvest that was non-research related in 2011-2018 have varied between 1 and 6.5 t, but has increased in recent years, surpassing AFSC longline survey research catch for the first time in 2018. The non-commercial removals show that a little over 15.5 t of shortraker rockfish was taken in 2018 during research cruises and in sport fisheries (Table 11A-1). Nearly equal amounts (between 5 – 6 t) have been taken in longline surveys by either the International Pacific Halibut Commission or the NMFS Alaska Fishery Science Center, and the NMFS trawl survey since 2011. This total was ~5% of the reported commercial catch of 763 t for shortraker rockfish in 2018 (see Table 11-2 in the main document). Therefore, this presents no risk to the stock especially because commercial catches in recent years have been much less than ABCs.

Table 11A-1.--Estimated research and sport catches (t) of shortraker rockfish in the Gulf of Alaska in 2018, based on data provided by the NMFS Alaska Regional Office (AK R.O.). AFSC trawl = NMFS Alaska Fishery Science Center bottom trawl survey; IPHC longline = International Pacific Halibut Commission longline survey; AFSC longline = NMFS Alaska Fishery Science Center longline survey; ADFG PWS = Alaska Department of Fish and Game Prince William Sound sablefish tagging survey.

Source	AFSC trawl	IPHC longline	AFSC longline	ADFG PWS	Sport	Total
AK R.O.	-	4.00	5.06	-	6.48	15.53

Table 11A-2.--Catch (t) of shortraker rockfish taken during NMFS research cruises in the Gulf of Alaska, 1977-2018. Longline data refers only to catches in the AFSC longline survey and does not include the International Pacific Halibut Commission longline survey. (n.a.=not available; tr=trace).

	Gear		
Year	Trawl	Longline	Total
1977	0.1	0.0	0.1
1978	0.6	n.a.	0.6
1979	0.5	n.a.	0.5
1980	1.0	n.a.	1.0
1981	6.2	n.a.	6.2
1982	2.4	n.a.	2.4
1983	0.2	n.a.	0.2
1984	6.8	n.a.	6.8
1985	3.5	n.a.	3.5
1986	0.9	n.a.	0.9
1987	15.5	n.a.	15.5
1988	0.0	n.a.	0.0
1989	0.1	n.a.	0.1
1990	2.4	n.a.	2.4
1991	tr	n.a.	tr
1992	0.1	n.a.	0.1
1993	3.0	n.a.	3.0
1994	0.1	n.a.	0.1
1995	tr	n.a.	tr
1996	4.3	5.9	10.2
1997	0.0	11.1	11.1
1998	20.7	9.7	30.4
1999	101.5	8.1	109.6
2000	0.0	10.0	10.0
2001	1.0	7.1	8.1
2002	0.5	6.1	6.6
2003	4.3	5.5	9.8
2004	0.0	4.7	4.7
2005	4.1	4.5	8.6
2006	0.0	6.0	6.0
2007	4.7	7.9	12.6
2008	0.0	8.4	8.4
2009	8.3	6.7	15.0
2010	0.0	4.2	4.2
2011	4.6	6.7	11.3
2012	0.0	5.3	5.3
2013	5	4.1	9.1
2014	0.0	6.8	6.83
2015	6.1	5.9	12
2016	0.0	5.0	5.0
2017	2.9	5.8	8.7
2018	0.0	5.1	5.1